The Relationship between Public Debt and Economic Growth: Nonlinearity and Country-Specificity

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Abstract

After having tested whether public debt GDP ratio and real GDP per capita are cointegrated, the possible nonlinearity in the relationship between public debt GDP ratio and economic growth is examined for 17 OECD countries taken separately over the 1970-2014 period. The corresponding debt-value threshold is endogenously estimated following Hansen (1996, 1999)'s methodology, while simultaneously controlling for additional growth determinants. The findings reveal that the impact of the public debt ratio on economic growth, cointegration and nonlinearity between these two variables, as well as the debt-value thresholds are all country-specific. Thus, analyzing the link between public debt ratio and economic growth for one country individually is revealed to be essential for governments to shape appropriate fiscal policy guidelines.

Keywords: Public Debt; Economic Growth; Cointegration; Endogenous; Threshold, Nonlinearity

JEL codes: E62; H63; O40; C24;C32

1. Introduction

Over the past decade, and in particular in the aftermath of the economic and financial crisis that started in 2008, fiscal sustainability has deteriorated markedly in many European countries (see European Commission's Debt Sustainability Monitor 2016 (2017)). This reflects large current fiscal deficits, high levels of debt, forecasts of moderate to low GDP growth, which comes in addition to the huge future costs of an ageing population that is projected to have considerable fiscal implications in most countries. The economic and financial crisis of 2008 and the difficulties related to the expansion of the public debt in industrial countries led to a substantial worsening of public finances in many advanced countries and, consequently, to a renewed interest in the relation between public debt and economic growth among policy-makers and economists. Indeed, a good understanding of the relation between debt and growth is crucial for an adequate guidance of public policies.

In order to achieve development and growth, a country needs resources. A country may be able to generate some of them domestically but often it needs to borrow from the international capital market, which can lead to high levels of debt. The theoretical models exploring the debt-growth relationship can be grouped in three types. The first type of models, neo classical growth models, claim that a reasonably (low) level of debt stimulates growth (through, for instance, an increase of disposable income and of aggregate demand); public debt has a positive impact on GDP growth due to the stimulus effects of fiscal policy. The second type of models (see Krugman (1988) for instance), which support the debt overhang hypothesis, argue that a very large debt stock has detrimental effects on growth. For instance, it can create higher future taxes and/or interest rates that will negatively influence growth in investment and consumption, which in turns will result in less employment and lower output growth. The final type of models combines these two ideas and states that there is a nonlinear debt-growth relationship (see Pattillo et al. (2002) for instance). This view suggests that in the early stages of borrowing, when the debt level is modest, debt enhances growth while in the later stages, when debt is too high, it inhibits growth. This would imply that there is a critical debt threshold below which debt enhances growth but above which debt deters growth.

Since the latest global debt crisis and in particular the analysis of Reinhart and Rogoff (2010a,b), most empirical papers on the debt-growth topic take as given the nonlinear nature of the debt-growth relationship and consider a common debt-to-GDP threshold among countries. However, several authors have recently questioned these premises. According to Egert (2015a, 2015b) and Panizza and Presbitero (2013), the presence and the level of the estimated thresholds are not robust to small changes in country coverage, empirical techniques and/or frequency of data. Regarding the relations between debt and growth, Herndon et al. (2014) suggest that there is

no nonlinearity and Kourtellos et al. (2013) find that there is little evidence supporting nonlinearity. Furthermore, the literature on this topic also indicates that the impact of debt on economic growth is not necessarily positive below the debt-threshold and negative above it. For example, Chang and Chiang (2012) find that this effect is positive in both regimes (further examples are given by Dafermos (2015)). Misztal (2010) and Bell et al. (2015), who analyzed developed countries, as well as Eberhardt and Presbitero (2015), who worked on developing, emerging and developed economies, conclude that the relation between public debt and growth is heterogeneous among countries. Eberhardt (2013) enumerates various reasons that would justify why the link between debt and growth might differ among countries; it depends on variables such as the income level or debt composition, on the reasons why debt has been accumulated, on whether debt has been consumed or invested (if so, in which economic activities) and/or on the capacity of the country to tolerate high amounts of debt, which might be influenced by its macroeconomic and institutional characteristics. However, it is important to note that, with the exception of Egert (2015b) and Eberhardt (2013), none of the recent studies examine the link between public debt and economic growth or the existence of a debt-value threshold for each country individually, which is the aim of the present study.

Our paper contributes to the existing literature in several ways. First, contrary to most papers, we consider the possibility that public debt ratio and GDP per capita might be cointegrated and we perform the appropriate test for this hypothesis by means of the bounds testing procedure developed by Pesaran et al. (2001). Second, we examine the relationship between public debt GDP ratio and economic growth for each country taken separately and test whether it is nonlinear. The possible debt-value threshold is then endogenously estimated following Hansen's (1996, 1999) methodology for each country. Third, contrary to Egert (2015b) and Eberhardt (2013), we perform this analysis while controlling simultaneously for additional determinants of economic growth. Applied to a large dataset of industrial countries, this unique combination of alternative tests and specifications provides a thorough and up-to-date analysis of the controversial link between growth and public debt.

The remainder of this paper proceeds as follow. Section 2 provides a review of the literature on the relation between GDP and debt. Section 3 describes the data as well as the econometric frameworks for testing cointegration between public debt ratio and GDP per capita, examining the relationship between these two variables and determining whether a debt-value threshold exists. Section 4 presents the empirical findings, while section 5 discusses the results. Section 6 concludes.

2. Literature Survey

We report below the main results of recent studies on the link between public debt and economic growth, which are diverse in terms of data (time and country) coverage and empirical methodology. For reasons of clarity, we divide them into two main groups: the first one for studies in which the debt-value threshold is determined exogenously and the second one for studies in which the debt-value threshold is endogenous.

2.1 Debt threshold determined exogenously

On the basis of correlation statistics between debt and growth, Reinhart and Rogoff (2010a and 2010b) consider 44 countries from the year 1790 to 2009 and conclude that GDP growth rates for countries with public debt over 90% of GDP are significantly lower than if they didn't have such a high level of debt. By means of various time series methods (polynomial functions or piecewise linear (threshold) specifications), Eberhardt (2013) analyzes two centuries of data for four industrialized countries and finds no evidence for a linear or a nonlinear long-run relationship between debt and growth. His results also show that this link varies across countries. In their study, Eberhardt and Presbitero (2013) analyze a panel of 105 countries over the period 1972 to 2009. They take into account nonlinearities in both the cross-country and within-country dimensions by means of heterogeneous dynamic ECM within a standard growth model and static regression models with squared and cubed debt terms. They test the existence of three possible debt (% GDP) threshold values: 52% (the sample median), 75% and 90%. They find some support for a nonlinear relationship between debt and long-run growth across countries, but no evidence supporting a common debt threshold within countries over time. Afonso and Alves (2014) consider 14 European countries over the 1970-2012 period. They study the effect of public debt on economic growth and on the basis of quadratic models, the authors find that average debt ratio thresholds lie around 75% depending on the econometric method used and on the set of variables. After having identified and corrected several errors in Reinhart and Rogoff (2010a,b), Herndon et al. (2014) replicated these authors' much cited analysis and in contrast find that average GDP growth at public debt/GDP ratios over 90 percent is not dramatically different than when debt/GDP ratios are lower. They also show that the debt-growth relation vary among countries and time periods. By means of panel vector autoregressions, Lof and Malinen (2014) analyze data on 20 developed countries over the period 1905–2008 and find no evidence for a robust effect of debt on growth, even for higher levels of debt. In addition they come to the conclusion that this effect is ambiguous. On the basis of the data used by Reinhart and Rogoff (2010a), Bell et al. (2015) examine the link between growth and debt in developed countries. The authors use multilevel models and find that the debt-growth link vary across countries and that the explanatory power of debt on growth is poor. Eberhardt and Presbitero (2015)

database includes data from 1961 to 2012 for 118 countries. Their linear and nonlinear regression models take into account heterogeneity across the considered countries through a common correlated effects (CCE) estimator. The authors test the presence of prespecified debt GDP ratio threshold value (60% and 90%) and find some support for a negative relationship between public debt and long-run growth across countries, but do not report any evidence for a common debt threshold within countries. Kumar and Woo (2015) analyze the impact of high public debt on long-run economic growth in 38 advanced and emerging economies over 38 years (1970-2007) using growth regressions. In order to analyze potential nonlinearities, they include in the specifications interaction terms between initial debt and dummy variables for various ranges of initial debt. Their result suggest an inverse relation between initial debt and subsequent growth and some evidence of nonlinearity, according to which high levels of debt (above 90% of GDP) have a significant negative effect on growth.

2.2 Debt threshold determined endogenously

This category of studies is further divided into two sub-groups. The first one describes the studies in which the debt-value threshold is determined by means of the Hansen's (1996, 1999) methodology, which is used in this paper and described in details in Section 3 below. In addition to allow the determination of the threshold's level endogenously, this methodology has several advantages. It allows to estimate simultaneously the threshold level, the coefficients of the different regimes and the ones of the other explanatory variables by OLS. This methodology also allows the calculation of an asymptotic p-value for the null hypothesis of no threshold effect (i.e. linearity) using simple simulation techniques. In addition, it can also be mentioned that this technique doesn't impose any specific functional form of nonlinearity for the analyzed relationship (Nasa (2009)). The papers using other techniques are listed in the second sub-group.

2.2.1 Studies using Hansen threshold methodology (1996, 1999)

Nasa (2009) attempts to endogenously determine the sustainable level of debt for 56 low and medium income countries over the period 1970-2000. The results suggest that debt becomes detrimental to growth once the debt-to-GDP ratio is greater or equal to 45% and that a debt-to-GDP ratio of 7% is the growth maximizing level of debt. Caner et al. (2010) consider 99 developing and developed countries over the period 1980-2008 in order to find the tipping point when public debt starts to have a negative impact on economic growth. They find that if the debt-to-GDP ratio is above 77%, each additional percentage point of debt creates a decrease of 0.017 percentage points of real growth. Their results also indicate that this effect is stronger in developing countries, where the threshold amounts to 64% debt-to-GDP ratio. Considering a panel of 18 OECD countries over 1980 to

2010, Cecchetti et al. (2011) use a panel threshold approach inspired by Hansen (1999). They find that when the level of government debt is higher than 85% of GDP, the debt has a negative impact on economic growth. Afonso and Jalles (2013) use a panel of 155 developed and developing countries over the period 1970-2008. They estimate growth equations as well as the debt threshold. The authors find that economic growth is lower when the value of debt ratio is greater than 59%. Baum et al. (2013) analyze the nonlinear impact of public debt on GDP growth by extending the threshold panel methodology by Hansen (1999) to a dynamic setting. They focus on 12 European countries for the period 1990-2010. Their results suggest that the short-run impact of debt on GDP growth is positive and statistically significant. However, beyond the public debt-to-GDP ratios of 67%, the short-run impact decreases to zero and is not statistically significant any more. Egert (2015a) considers 44 countries and two periods i.e. 1790 to 2009 or 1946 to 2009 (dataset of Reinhart and Rogoff (2010a)). On the basis of bivariate regressions, the author finds some evidence of a negative nonlinear relation between debt and growth with a debt threshold lying between 20% and 60% of GDP. However, the author clearly points out that these results, including the nonlinearity of the link between public debt and growth, are not robust. Egert (2015b) uses the same dataset as Reinhart and Rogoff (2010a) and estimates bivariate threshold models. The results indicate that the nonlinear relation between debt and growth is not robust. There might be a tipping point at around 20% of GDP but this outcome must be considered with caution. In order to consider that the impact of public debt on economic growth might be country-specific, Egert (2015b) performs the same analyses for individual countries, which reveal that cross-country heterogeneity is very important. Swamy (2015a) considers 252 countries over the period 1960-2009 in order to analyze the relationship between government debt and economic growth. The author groups the countries according to various criteria such as the type of political governance or the level of income. The findings show that the debt thresholds may vary between 84 and 114 percent of GDP according the different groups of countries and that above the debt-threshold, an increase of debt is detrimental to economic growth. Among all the studies listed in Section 2.2.1, Egert (2015b) is the only one who uses time series estimation techniques and his analysis is the most closely related to the present paper. However, one must note that this author only estimates bivariate specifications, as public debt is the only explanatory variable for GDP growth.

2.2.2 Studies using other methodologies

Chang and Chiang (2012) use a Panel Smooth Transition Regression (PSTR) model to analyze 19 OECD countries over the period 1993-2007. They find that there is one threshold value of 97.82% above which growth is lower than if the level of debt was under the threshold value. However, they also conclude that the impact of debt on GDP growth is positive on both sides of the threshold. Checherita-Westphal and Rother (2012) investigate the average impact of government debt on per-capita GDP growth in 12 European countries over a period of around 40 years starting in 1970. They perform growth regressions quadratic in debt and control for various growth determinants. Their results indicate that the impact of debt on growth is nonlinear with a turning point – beyond which the government debt-to-GDP ratio has a negative impact on long-term growth – at about 90-100% of GDP. Minea and Parent (2012) use a PSTR method in order to check the relevance of the debt-to-GDP ratio threshold of 90% found by Reinhart and Rogoff (2010b). The authors consider 20 advanced economies over the period 1945 to 2009. Like Reinhart and Rogoff (2010b), they find that a debt-to-GDP ratio above 90% reduces average economic growth but that this contraction of economic growth is not statistically significant. They also find that when debt-to-GDP ratio is above 115%, the impact of public debt on GDP can be positive. Presbitero (2012) explores the impact of public debt on growth for a panel of 92 developing countries over the period 1990-2007. The author uses growth equations estimated by System GMM and models nonlinearities in three different ways: quadratic functional form, spline specification and interaction of public debt with the overall Country Policy and Institutional Assessment (CPIA) score (which takes into account the role of policies and institutions on economic development). This study shows that public debt has a negative impact on output growth up to a threshold of 90% of GDP, beyond which its effect is irrelevant. In their study, Kourtellos et al. (2013) analyze a panel of 82 countries covering the period 1980 to 2009. They use a structural threshold regression methodology and find that there is little evidence of nonlinearity between public debt and growth. Furthermore, their results suggest that the link between these two variables depends on the quality of the institutions of the studied countries. Swamy (2015b) investigates the government debt – growth relationship for several groups of countries and take into account economic, political and regional diversities. On the basis of a dataset containing 252 countries over the period 1960-2009, considering a quadratic functional form and by means of several different panel data models, the author finds that the link between debt and growth is negative and nonlinear. Using dynamic heterogeneous panel data models with cross-sectionally dependent errors, Chudik et al. (2017) analyze the relation between public debt and economic growth. The authors consider 40 advanced and developing countries over the 1965 to 2010 period and find that public debt has negative long-run effects on

economic growth and that there is no evidence for a universal threshold effect in the relationship between these two variables.

3. Methodology

The purpose of this paper is to study the relationship between public debt GDP ratio and economic growth. The estimation's procedure consists in several steps. First, the possible cointegration between public debt GDP ratio and GDP per capita growth is tested by means of the bounds testing approach developed by Pesaran et al. (2001). This methodology has the advantage that, contrary to the Engle and Granger (1987) procedure, it can be applied even if the variables are not integrated of the same order. The order of integration must however not be higher than 1. Once the autoregressive distributed lag (ARDL) linear model (i.e. without threshold effects) resulting from the bounds testing approach has been determined, the corresponding threshold model is estimated following Hansen's (1996, 1999) methodology. As mentioned above, the latter has several advantages. The threshold's level is determined endogenously and is simultaneously estimated with the coefficients of all the variables included in the specification. The different equations are estimated by OLS and this methodology also allows the calculation of an asymptotic p-value for the null hypothesis of no threshold effect using simple simulation techniques. In addition, contrary to the estimation of quadratic specification for instance, this technique doesn't impose any specific functional form of nonlinearity for the analyzed relationship. The next step of the estimation's procedure consists in testing the threshold model against the linear model using a bootstrapping method developed by Hansen (1996). Finally, we test for the significance of the threshold by means of a likelihood ratio (LR)-type statistic[1].

3.1 Cointegration test and linear model

In order to test whether real GDP per capita growth and public debt GDP ratio are cointegrated, the bounds testing procedure developed by Pesaran et al. (2001) is used. This approach has the advantage that it is not necessary for the variables of interest to be integrated of the same order. However, the latter must be lower than 2. In this study, the integration order of the variables is determined by means of the augmented Dickey-Fuller

[1] Although encompassing in a single framework most of the empirical caveats identified by the literature, our methodology does not test for the presence of a threshold in the equilibrium correction mechanism itself. This implies that the long-run equation is assumed to remain identical whatever the level of the public debt ratio and that only short-run asymmetries are considered (as in Mehrara et al. (2010) or Bastianin et al. (2014), for example). Ideally, both long-run and short-run asymmetries should be simultaneously tested. However, to our knowledge, no methodology allowing to perform these two tests simultaneously currently exists and developing one would be beyond the scope of the present paper.

(ADF) test[2]. Various growth determinants (denoted by x_2 to x_m) are introduced in the econometric specification in order to improve the fit of the model. In order to perform bounds testing, we follow the procedure described by Giles (2013). If the variables' integration order is lower than 2, the following equation is formulated:

$$\begin{aligned}\Delta GDP_t = c + \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + \\ + \theta_0 GDP_{t-1} + \theta_1 debt_{t-1} + \theta_2 x_{2,t-1} + \ldots + \theta_m x_{m,t-1} + e_t\end{aligned} \quad (1)$$

where Δ indicates the first difference operator, GDP real GDP per capita growth (the dependent variable), debt the public debt to GDP ratio, k and l the autoregressive order of these two variables and e_t the error term (independent and identically distributed with mean zero and finite variance). Equation (1) represents the "conditional" ECM (see Pesaran et al. (2001) p. 292), which is a particular type of ARDL model, and will be used to perform the cointegration test.

We begin this test procedure by determining the optimal number of lags of the two variables of interest according to the Schwarz (Bayes) criterion (SC). In this study, as the number of observations is relatively low, the maximum number of lags of the two variables of interest is limited to 2. Furthermore, only the contemporaneous value of each additional right-hand-side variables is considered[3]. The next step consists in testing the possible serial correlation of the errors. For this purpose, we refer to the Breusch-Godfrey Serial Correlation LM test. Finally, it is necessary to test whether the ARDL model is stable. This consists in checking that all the inverse roots of the characteristic equation associated with our model lie strictly inside the unit circle[4]. After having performed these tests, the bounds testing procedure can be applied by performing an "F-test" of the hypothesis H_0: $\theta_0 = \theta_1 = \theta_2 = \ldots = \theta_m = 0$ (against the alternative that H_0 is rejected). As explained by Giles (2013),"this corresponds to, like in conventional cointegration testing, a test for the absence of a long-run equilibrium relationship between the variables". Thus, a rejection of H_0 implies that we have a long-run relationship. For small samples, which is the case in this study, it is appropriate to refer to the bounds on the critical values of the F-statistic provided by Narayan (2005).

[2] The null hypothesis is that the series has a unit root.

[3] If we let vary the number of lags of the additional growth determinants, the number of explanatory variables can be up to 32 in equation (1). As the number of observations is around 40, the number of degrees of freedom would be too low. Furthermore, this would imply that in the threshold specification (see equations (5) and (6) the number of parameters could be higher that the number of observations).

[4] If the errors are not serially independent or the ARDL model is not stable, the optimal number of lags are determined according to the second lowest value of the SIC criterion, and so on.

If the bounds test leads to the conclusion of cointegration, the long-run equilibrium relationship between the variables can be estimated by the following equation:

$$GDP_t = \tau + \rho debt_t + \partial_2 x_{2,t} + \ldots + \partial_m x_{m,t} + \upsilon_t \quad (2)$$

The corresponding usual ECM is:

$$\Delta GDP_t = \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \varphi \hat{z}_{t-1} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + e_t \quad (3)$$

where $\hat{z}_{t-1} = GDP_{t-1} - \hat{\tau} - \hat{\rho} debt_{t-1} - \hat{\partial}_2 x_{2,t} - \ldots - \hat{\partial}_m x_{m,t}$

and is the error correction term[5]. The magnitude of the coefficient of the error term represents the percentage at which any disequilibrium between GDP and the right-hand-side variables is corrected within one period. In order to validate this "final" ECM model, the coefficient of the error correction term must lie between -1 and 0 and be statistically significant[6].

If there are no statistically significant long-run effects or if the ECM is not validated, the final model is (see Marques et al. (2016) for example):

$$\Delta GDP_t = \xi + \sum_{i=1}^{k} \alpha_i \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j \Delta debt_{t-j} + \kappa_2 \Delta x_{2,t} + \ldots + \kappa_m \Delta x_{m,t} + \mu_t \quad (4)$$

Whatever the case, i.e. whether the final model is given by equation (3) or (4), the model must be stable and the errors serially independent[6].

One must note that the link between the different variables may not be linear. This calls for further investigation, as illustrated in the following subsection.

3.2 Threshold model

In order to estimate the possible asymmetric relation between real GDP per capita growth and public debt ratio, a threshold autoregressive (TAR) mechanism is added to the linear model. The resulting model is referred to as the TAR specification (when the ECM representation is validated, it is referred to as the TAR-ECM specification). The TAR (-ECM) model assumes that the regime is determined by a variable, here $debt_t$, relative to a threshold

[5] It represents the speed at which the dependent variable returns to its long-run equilibrium value after a change in the independent variable.

[6] If the model is not stable or if the errors are not serially independent, the optimal number of lags are determined according to the second lowest value of the SIC criterion, and so on.

value. If the relation between real GDP per capita growth and public debt ratio is asymmetric, the impact of the latter variable would be different in each regime. A two-regime TAR-ECM has the following form:

$$\Delta GDP_t = \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \varphi \hat{z}_{t-1} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + \\ + \left(\sum_{j=0}^{l} b_j^* \Delta debt_{t-j} \right) \mathbb{1}\left(debt_t > \bar{d} \right) + e_t \quad (5)$$

Grasso and Manera (2007 / p. 11) explain that in equation (5), $debt_t$ "is the threshold variable, which is a continuous and stationary transformation of the data, and $\bar{d} \in \Gamma$ is the threshold parameter (in the linear model, it is equal to zero)". The authors further indicate that "the region denoted by Γ is typically selected by sorting the observations on the threshold variable into an increasing order; the resulting model is well identified for all possible thresholds. The error term e_t is assumed to be independent and identically distributed with mean zero and finite variance. The function *1()* indicates whether or not the threshold variable is above the threshold". Similarly to Baum et al. (2013), we consider the possible change of coefficients in the different regimes only for public debt to GDP ratio. This implies that the slope of the other variables remain the same in each regime. The regression coefficients are $(a_i, b_j, \phi, \partial_2, \ldots, \partial_m)$ if $debt_t \leq$d, and $(a_i, b_j+b_j^*, \phi, \partial_2, \ldots, \partial_m)$ if $debt_t >$d. The coefficients of the first group correspond to the regime of lower values of $debt_t$ and those of the second group correspond to the regime of upper values of $debt_t$.

If the ECM representation is not validated, the corresponding TAR equation is the following:

$$\Delta GDP_t = \xi + \sum_{i=1}^{k} \alpha_i \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j \Delta debt_{t-j} + \kappa_2 \Delta x_{2,t} + \ldots + \kappa_m \Delta x_{m,t} + \\ + \left(\sum_{j=0}^{l} \beta_j^* \Delta debt_{t-j} \right) \mathbb{1}\left(debt_t > \bar{d} \right) + \mu_t \quad (6)$$

In this case, the coefficients of the lower regime are $(\zeta, \alpha_i, \beta_j, \kappa_2, \ldots, \kappa_m)$ and the ones of the upper regime are $(\zeta, \alpha_i, \beta_j+\beta_j^*, \kappa_2, \ldots, \kappa_m)$.

In the robustness test section, we will consider a possible change of the coefficients of all the explanatory variables in the different regimes. In that case, the two-regime TAR-ECM has the following form:

$$\Delta GDP_t = \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \varphi \hat{z}_{t-1} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + \\ + \left(\sum_{i=1}^{k} a_i^* \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j^* \Delta debt_{t-j} + \varphi^* \hat{z}_{t-1} + \partial_2^* \Delta x_{2,t} + \ldots + \partial_m^* \Delta x_{m,t} \right) \mathbb{1}\left(debt_t > \bar{d} \right) + e_t \quad (7)$$

The regression coefficients are $(a_i, b_j, \phi, \partial_2, \ldots, \partial_m)$ if $debt_t \leq$d, and $(a_i+a_i^*, b_j+b_j^*, \phi+\phi^*, \partial_2+\partial_2^*, \ldots, \partial_m+\partial_m^*)$ if $debt_t >$d. If the ECM representation is not validated, the corresponding TAR equation is the following:

$$\Delta GDP_t = \xi + \sum_{i=1}^{k} \alpha_i \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j \Delta debt_{t-j} + \kappa_2 \Delta x_{2,t} + \ldots + \kappa_m \Delta x_{m,t} + \\ + \left(\xi^* + \sum_{i=1}^{k} \alpha_i^* \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j^* \Delta debt_{t-j} + \kappa_2^* \Delta x_{2,t} + \ldots + \kappa_m^* \Delta x_{m,t}\right) \mathbb{1}\left(debt_t > \bar{d}\right) + \mu_t \quad (8)$$

The regression coefficients are *(ζ, α_i, β_j, κ_2, ..., κ_m)* if $debt_t \leq$d, and *(ζ+ζ*,α_i+α_i*,β_j+β_j*,κ_2+κ_2*,...,κ_m+κ_m*)* if $debt_t >$d.

As mentioned by Mehrara et al. (2010 / p. 7), "the threshold value $\bar{d}$ is unknown and should be estimated in addition to other parameters of the TAR(-ECM) model". The authors also refer to Chan (1993) who showed that, since the threshold equation is nonlinear and discontinuous, the parameter estimates can be obtained by sequential conditional least squares. This procedure consists in running least squares regressions on equations (5) and (6), as well as on (7) and (8), using all possible values of the threshold ($\bar{d} \in \Gamma$) and selecting the threshold's estimate, $\hat{\bar{d}}$, as the argument that minimizes the sum of squared residuals, denoted by $S(\bar{d})$, i.e. : $S(\hat{\bar{d}}) = \inf_{\bar{d} \in \Gamma} S(\bar{d})$.

3.2.1 Test of the threshold model against the linear model

The next step consists in testing the threshold model (equations (5) or (7) and (6) or (8)) relative to the corresponding linear model (equations (3) and (4)). Referring to the description of Grasso and Manera (2007), the null hypothesis (linearity) is H_0: $b_0^* = b_1^* = \ldots = b_m^* = 0$ when the error correction mechanism is validated. When the error correction mechanism is not validated, the null hypothesis is H_0: $\beta_0^* = \beta_1^* = \ldots = \beta_m^* = 0$. The test statistic for linearity is:

$$F = T(\tilde{S} - S(\hat{\bar{d}}))/S(\hat{\bar{d}}) \quad (9)$$

with *S* being the estimated residual variance of the corresponding linear model. As noted by Grasso and Manera (2007 / p. 162), "the distribution of *F* in expression (9) is non-standard, as the threshold is not identified under the null hypothesis of linearity". We follow these authors and apply the bootstrapping procedure developed by Hansen (1996) to approximate the asymptotic distribution of *F*. On a total of *1000* bootstrap samples, the asymptotic p-value is the share of bootstrap samples for which the bootstrap statistic exceeds *F*.

3.2.2 Test of the significance of the threshold

In order to examine the statistical significance of the threshold estimate, we consider the null hypothesis $H_0: \overline{d_0} = \bar{d}$, where $\overline{d_0}$ is the true value and $\bar{d}$ is a generic value, and we use a likelihood ratio-type statistic[7]:

$$LR(\bar{d}) = T(S(\bar{d}) - S(\hat{\bar{d}}))/S(\hat{\bar{d}}) \tag{10}$$

where T is the number of observations, $\hat{\bar{d}}$ is the threshold that minimizes the sum of squared residuals in equations (5) to (8) (i.e. the estimated threshold) and $\bar{d}$ is a generic value of the threshold. This statistic is compared with the critical value tabulated in Hansen (2000)[8] as this likelihood ratio (LR) test does not have the usual χ^2 distribution. The confidence interval (CI) for the estimated threshold can be found graphically by plotting the LR sequence in $\bar{d}$, LR($\bar{d}$), against $\bar{d}$ and drawing a horizontal line at the desired level of asymptotic critical values provided by Hansen (2000). The portion of the graph lying below the horizontal line is the "no rejection" region, i.e. the CI of the point estimate. The threshold point is where the LR is minimized and the CI occurs where the horizontal line crosses the curve. However, when the critical values lay above all the calculated LR statistics, it is not possible to compute the intervals for the threshold.

4. Empirical results

4.1 Data

In this study, we use data from 17 industrialized countries over the period 1970 - 2014. The considered variables are the general government consolidated gross debt (percentage of GDP), real GDP per capita in (constant 2005) US dollars[9], gross fixed capital formation (GDP ratio, as a proxy for domestic investment), openness to trade (defined as the sum of exports and imports over (nominal) GDP), inflation (GDP deflator), general government final consumption expenditure (% of GDP), population growth, and school enrollment at the secondary level (% gross). See Appendix A and table D.1 in the Appendix D for the variables definition and for each country's data summary. All data are available from the World Bank (World Development Indicators database) except the series for the general government consolidated gross debt, which come from Eurostat (the Statistical Office of

[7] By definition this statistic equals zero at the estimated threshold level.

[8] The critical value for the 95% and the 99% are 7.35 and 10.59 (see Hansen (2000) Table 1, page 582).

[9] The variable "GDP, Purchasing Power Parity (PPP) (constant international $)" was not available for the considered period for each analyzed country. However, this is inconsequential in terms of growth rates.

the European Commission). These explanatory variables are selected according to their availability, as is the choice of the countries considered in the data sample.

4.2 ECM or not?

According to the augmented Dickey-Fuller unit root test, no series has an integration order larger than 1 (see table D.2 in the Appendix). Thus, it is possible to use the bounds testing approach in order to test whether the variables are cointegrated. Table D.3 (see Appendix) lists the optimal number of lags for real GDP per capita and public debt ratio, which is determined according to the Schwarz (Bayes) criterion (SC). As mentioned in section 3.1, the maximum number of lags is 2. However, for Ireland, we let the number of lags be up to 4. Otherwise, it is not possible to get a specification which is stable and has no serial error correlation. In order to test for the presence of serial autocorrelation, the Breusch-Godfrey Serial Correlation LM test is applied (see also table D.3). Finally, the results of the stability test of the model are reported in table D.4[10].

Once these tests have been performed, the cointegration test, which consists in a test of the hypothesis H_0: $\theta_0 = \theta_1 = \theta_2 = \ldots = \theta_m = 0$ (see equation (1)), can finally be applied[11]. The results are also reported in table D.3 and indicate that for all countries but Ireland the null hypothesis is rejected, which means that there is a long-run relationship between real GDP per capita and public debt ratio. However, after having estimated the usual ECM (see equation (3)) for each country, the results indicate that the error correction specification is finally only validated - i.e. the error correction term[12] is statistically significant and its coefficient lies between -1 and 0[13] - for the following countries: Belgium, Canada, Denmark, Luxembourg and Spain (see table 1 for the long-run equations and table 3 for the corresponding ECM's results). For the other countries, the coefficient of the error correction term is lower than *-1*, which implies that the ECM specification is not validated.

[10] If the errors are not serially independent or if the model is not stable, the optimal number of lags are determined according to the second lowest value of the SIC criterion and so on.

[11] We refer to the tables provided by Narayan (2005) for the bounds on the critical values of the F-statistic.

[12] This term measures the speed at which deviations of the dependent variable from its long-run equilibrium are corrected.

[13] Furthermore, the errors are serially independent.

Table 1: Long-run equations

Dependent variable: Real GDP per capita growth

	Belgium	Canada	Denmark	Luxembourg	Spain
Public debt ratio	-0.038	-0.101	-0.032	0.120	-0.025
	*0.022***	*0.269*	*0.344*	*0.371*	*0.353*
Government consumption	-0.669	-0.126	0.687	-1.216	0.188
	*0.002****	*0.830*	*0.216*	*0.009****	*0.635*
Gross fixed capital formation	-0.159	-0.150	0.148	0.074	0.116
	0.339	*0.565*	*0.531*	*0.799*	*0.797*
Openness to trade	-2.472	1.885	-16.121	1.190	-2.025
	0.342	*0.837*	*0.021***	*0.444*	*0.706*
GDP deflator	-0.308	-0.315	-0.043	-0.666	-0.170
	*0.007****	*0.200*	*0.743*	*0.005****	*0.580*
School enrollment	-0.013	0.036	0.066	-0.009	-0.063
	0.411	*0.820*	*0.108*	*0.895*	*0.244*
Population growth	-70.322	225.097	72.460	-239.190	-194.584
	0.638	*0.293*	*0.714*	*0.020***	*0.467*
Constant	29.644	8.859	-12.246	21.812	7.715
	*0.000****	*0.716*	*0.384*	*0.001****	*0.044***

All the variables are in levels

p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

4.3 Linear specifications or threshold?

After having estimated the linear specification (equations (3) and (4)), the (ECM-)TAR model (equations (5) and (6)) is also estimated by OLS[14] for each country. Then, the test of the threshold model relative to the linear model (asymptotic bootstrap p-value) is performed. Table 2 reports for each country the threshold that minimizes the sum of squared residuals, the corresponding F-statistic (equation (9)) and the asymptotic bootstrap p-value. The results indicate that the threshold specification is only validated (p-value lower than 0,1) for four countries (out of 17): Finland, Great Britain, Italy and the Netherlands.

[14] The standard errors are robust to heteroscedasticity.

Table 2: Threshold that minimizes SSR, F statistic and bootstrap p-value

Countries	**Threshold of public debt ratio (% GDP) that minimizes SSR**	**F Statistic**	**Bootstrap p-value[1]**
Austria	26.1	8.1	0.745
Belgium	65.8	8.8	0.696
Canada	70.7	6.8	0.442
Denmark	63.2	3.9	1.000
Finland	**52.2**	**54.4**	**0.003**
France	26.8	15.1	0.187
Great Britain	**50.2**	**21.7**	**0.015**
Greece	21.2	24.6	0.193
Ireland	108.3	9.3	0.998
Italy	**56.3**	**29.9**	**0.090**
Japan	79.9	13.2	0.189
Luxembourg	12.4	7.2	0.936
Portugal	96.2	12.2	0.541
Spain	19.6	13.4	0.259
Sweden	37.6	9.6	0.152
The Netherlands	**48.9**	**22.9**	**0.043**
USA	99.0	7.7	0.399

[1] Generated on the basis of Hansen's (1996) procedure

4.3.1 Results of the linear model

The linear model estimations' results are reported in table 3. They show that the relationship between public debt ratio and economic growth is not the same among countries. This suggests that this link depends, among others, on the country's own characteristics, on its institutions, on the nature and the allocation of public debt, ...

Table 3: Linear specifications

Dependent variable: Real GDP per capita growth (in first differences)

	Austria	Belgium	Canada	Denmark	France	Greece	Ireland	Japan	Luxembourg	Portugal	Spain	Sweden	USA	The Netherlands[1]
Real GDP per capita growth (-1)	-0.246	-0.149	0.071	-0.18	-0.409	-0.403	-0.49	-0.528	-0.259	-0.555	0.042	-0.62	-0.56	-0.641
	*0.012***	*0.027***	*0.375*	*0.002****	*0.004****	*0.004****	*0.002****	*0.000****	*0.007****	*0.002****	*0.722*	*0.003****	*0.001****	*0.000****
Real GDP per capita growth (-2)							-0.378	-0.283	-0.188			-0.419		-0.064
							0.028**	0.065*	0.002***			0.008***		0.478
Real GDP per capita growth (-3)							-0.098							
							0.586							
Real GDP per capita growth (-4)							-0.267							
							0.062*							
Public debt ratio	0.108	-0.062	-0.143	-0.059	0.034	-0.11	-0.08	0.254	-0.518	-0.271	-0.261	0.023	0.179	-0.113
	0.186	*0.079**	*0.031***	*0.175*	*0.755*	*0.028***	*0.385*	*0.006****	*0.000****	*0.016***	*0.000****	*0.84*	*0.060**	*0.042***
Public debt ratio(-1)				0.097	0.26	-0.007	0.063		-0.381	0.259				0.016
				*0.008****	*0.014***	*0.9*	*0.509*		*0.002****	*0.041***				*0.659*
Public debt ratio(-2)						0.109	0.04							
						0.182	*0.649*							
ECT(-1)		-0.946	-0.86	-0.921					-0.898		-0.884			
		*0.000****	*0.000****	*0.000****					*0.000****		*0.000****			
Government consumption	-2.238	-1.642	-2.188	-0.548	-2.487	-1.833	-2.055	-5.634	-4.332	-0.326	-0.618	-2.098	-3.658	-1.482
	*0.073**	*0.000****	*0.000****	*0.024***	*0.000****	*0.007****	*0.009****	*0.000****	*0.000****	*0.65*	*0.179*	*0.000****	*0.000****	*0.003****
Gross fixed capital formation	-0.018	0.136	0.114	1.032	-0.045	0.359	0.107	0.171	0.078	0.359	0.619	0.258	0.683	0.88
	0.965	*0.431*	*0.629*	*0.000****	*0.915*	*0.297*	*0.7*	*0.609*	*0.452*	*0.145*	*0.002****	*0.452*	*0.242*	*0.011***
Openness to trade	22.316	7.857	8.371	0.459	5.28	-20.963	0.814	20.974	3.645	-1.352	-1.964	12.622	29.253	15.839
	*0.014***	*0.000****	*0.111*	*0.855*	*0.362*	*0.167*	*0.876*	*0.027***	*0.012***	*0.891*	*0.605*	*0.129*	*0.135*	*0.000****
GDP deflator	-1.466	-0.469	-0.341	-0.129	0.085	-0.333	-0.145	-0.517	-0.467	-0.349	-0.113	0.005	-0.815	-0.576
	*0.000****	*0.000****	*0.000****	*0.127*	*0.631*	*0.090**	*0.308*	*0.000****	*0.000****	*0.014***	*0.254*	*0.979*	*0.001****	*0.017***
School enrollment	0.064	-0.011	-0.145	-0.013	0.064	0.041	-0.064	0.113	0.089	-0.14	-0.042	0.005	-0.088	0.104
	0.563	*0.155*	*0.307*	*0.807*	*0.248*	*0.879*	*0.726*	*0.71*	*0.361*	*0.022***	*0.465*	*0.809*	*0.504*	*0.005****
Population growth	-19.099	-101.67	-96.987	524.082	240.111	404.064	144.788	121.104	271.089	-522.895	-171.892	-439.721	-445.862	-154.893
	0.907	*0.142*	*0.188*	*0.005****	*0.001****	*0.154*	*0.252*	*0.508*	*0.076**	*0.000****	*0.097**	*0.259*	*0.124*	*0.424*
Constant	-0.46				-0.536	0.428	-0.384	-0.516		-0.162		0.125	-0.734	-0.291
	0.119				*0.055**	*0.396*	*0.358*	*0.16*		*0.736*		*0.714*	*0.015***	*0.089**
Observations	37	41	37	41	35	37	38	38	40	38	41	40	41	37
R-squared	0.75	0.95	0.92	0.94	0.74	0.62	0.72	0.80	0.94	0.64	0.82	0.65	0.69	0.81

All the variables are in first-differences, except the error correction term (ECT)

p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

[1] According to the robustness test's results (see section 5.2), the debt-growth relationship in The Netherlands is linear.

Indeed, depending on the country, the impact of the public debt ratio on GDP per capita growth can be positive, negative or not statistically significant. A negative effect of public debt on GDP might be due, for instance, to the fact that higher debt can generate an increase of tax burden which negatively affects the economy's dynamism or leads to a higher interest rate, which would crowd-out investment. According to our results, this effect is observed in Belgium, Canada, Greece, Luxembourg, Portugal[15] and Spain. The influence of public debt might however also be positive as it is the case in Denmark, France, Japan and the USA. This might happen when public debt is efficiently consumed and/or invested. It might then be beneficial for economic growth through a stimulation of employment, consumption or investment, for example (see Eisner (1992)). Regarding Austria, Ireland and Sweden, GDP per capita growth is not influenced by public debt ratio but rather by further economic growth determinants such as government consumption for instance. This heterogeneity among countries suggests that in different economies having a similar level of public debt, the impact of this variable on economic growth will not necessarily be the same because of the influence of several other country-specific factors, including the composition of public debt and the way it is managed by the government. This heterogeneity is highlighted by several authors, such as Panizza and Presbitero (2013), Bell et al. (2015) and Chudik et al. (2017) for example, and suggests that governments must take into account their own countries' specificities in order to be able to shape appropriate fiscal policy measures. Indeed, expansionary fiscal policies do not necessarily have a positive impact on economic activity as other determinants also play a role in this relationship.

4.3.2 Results of the threshold model

As mentioned above, the threshold specification is validated for only four countries (out of 17), which are Finland, Great Britain, Italy and The Netherlands. The results presented in table 2 show that the debt-value threshold is different for each of these countries, which confirms, among others, Eberhardt (2013), Eberhardt and Presbitero (2013) and Egert (2015b). The debt-value threshold ranges from 48,9% to 56,3% depending on the country. Table 4 reports the threshold model's results.

[15] However, for this country, the coefficient of the one year lagged value is statistically significant and positive.

Table 4: Specifications with threshold

Dependent variable: Real GDP per capita growth (in first-differences)

	Finland	Great Britain	Italy	The Netherlands
Real GDP per capita growth (-1)	-0.225	-0.413	-0.324	-0.633
	*0.046***	*0.005****	*0.001****	*0.000****
Real GDP per capita growth (-2)				-0.13
				0.246
Public debt ratio (if Public debt ratio ≤threshold)	-0.22	0.047	-0.859	-0.756
	*0.037***	*0.514*	*0.003****	*0.000****
Public debt ratio (if Public debt ratio>threshold)	-0.159	-0.642	0.585	0.71
	0.259	*0.000****	*0.026***	*0.002****
Public debt ratio(-1) (if Public debt ratio ≤threshold)	0.754	0.145	1.151	0.306
	*0.000****	*0.108*	*0.000****	*0.009****
Public debt ratio(-1) (if Public debt ratio>threshold)	-0.404	0.53	-0.727	-0.326
	*0.025***	*0.004****	*0.003****	*0.010***
Public debt ratio(-2) (if Public debt ratio ≤threshold)	-0.208			
	0.188			
Public debt ratio(-2) (if Public debt ratio>threshold)	0.105			
	0.52			
ECT(-1) (if Public debt ratio ≤threshold)				
ECT(-1) (if Public debt ratio>threshold)				
Government consumption	-2.545	-0.624	0.092	-1.925
	*0.000****	*0.18*	*0.868*	*0.000****
Gross fixed capital formation	0.062	0.719	0.807	0.439
	0.591	*0.014***	*0.077**	*0.038***
Openness to trade	10.967	-1.554	18.033	12.488
	*0.011***	*0.861*	*0.023***	*0.000****
GDP deflator	-0.407	-0.429	-0.466	-0.607
	*0.000****	*0.001****	*0.000****	*0.002****
School enrollment	0.001	0.177	0.119	0.082
	0.954	*0.023***	*0.637*	*0.001****
Population growth	-391.029	251.122	57.877	30.834
	0.219	*0.653*	*0.773*	*0.849*
Constant	0.231	-0.03	-0.745	-0.173
	0.267	*0.917*	*0.031***	*0.29*
Observations	41	39	38	37
R-squared	0.937	0.769	0.877	0.879

All the variables are in first-differences, except the error correction term (ECT)

p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

In most cases, the impact of public debt ratio's growth in one country is not the same in both regimes. The sign of its coefficient, its intensity and its significance vary. Regarding Great-Britain, public debt ratio has a statistically significant impact on economic growth only when its value is above 50,2%; the contemporaneous value of public debt ratio has a negative impact on GDP per capita growth but the one of the previous year is positive. In the other countries (Finland, Italy and the Netherlands), when public debt ratio is below its threshold, its impact is negative during the current year but becomes positive one year after. These effects are the opposite when the public debt ratio is above the threshold. Thus, when the public debt ratio's level is relatively low, public debt's benefits are first overcome by its burden and the positive effects are realized only one year after. When the

public debt ratio is rather high, its effects on economic growth are positive during the current year (except in Finland where this effect is not statistically significant) but they become negative after one year.

Regarding the confidence interval of the threshold's value, the plots of the LR sequence against the estimated values of the threshold for these four countries are presented in figure D.1 in the Appendix. For each of these four countries, these graphics show that the estimated threshold's value lies in the "non rejection region". However, it can be observed that the confidence intervals are more accurate for Finland and The Netherlands than for Italy and Great Britain.

In short, the threshold model's results show that, in addition to be country specific, the relationship between public debt ratio and economic growth is not straightforward. It might be different according to the lag(s) of the public debt ratio variable and whether it is above or below its threshold. These two important results must be taken into account when establishing policies. Overall, the available evidence suggests that policy makers should be advised to consider that the link between public debt and economic growth as well as the eventual public debt ratio threshold are not universal but country-specific.

5. Discussion of the results

Our results' main conclusion is that the relationship between economic growth and public debt ratio vary among countries and that, for most of them, this link is linear (the debt-to-GDP threshold is statistically significant for only four countries out of 17). These two findings, which are confirmed by the ones of the robustness test section (see below), contradict mots papers on the debt-growth topic which state that not only the relationship between the two variables of interest is nonlinear but also that the debt-value threshold is common to all countries. Our conclusions are however also supported by several authors such as Bell et al. (2015) or Eberhardt and Presbitero (2015), for example.

The fact that the econometric specifications contain several lags of the public debt ratio variable makes it difficult to assess the sign of its impact on economic growth. In order to provide an estimate of this sign, it is possible, even if it is very rough, to sum up the public debt to GDP ratio variable's coefficients when they are statistically significant. Doing this exercise for the linear specifications tells us that public debt ratio's impact on economic growth is negative in about one third of the considered countries (i.e. in six countries: Belgium, Canada, Greece, Luxembourg, Portugal and Spain), positive in four countries (Denmark, France, Japan and the USA) and not statistically significant for the remaining three countries (Austria, Ireland and Sweden). Regarding the nonlinear specifications for Finland, Great Britain and Italy, the impact of public debt ratio on GDP per

capita growth is positive in the lower regime and negative in the upper one. The opposite is observed in the Netherlands. Because of the crude way the sign of the impact of public debt ratio on economic growth is calculated, these conclusions must be interpreted with caution. They are summarized in table 5.

Table 5: Results' summary

	Linear model	**Threshold model**	
		lower regime	upper regime
ECM not validated	fra^{+}, jpn^{+}, usa^{+}	fin^{+}, ita^{+}	nld^{+}
	grc^{-}, prt^{-}	nld^{-}	fin^{-}, gbr^{-}, ita^{-}
	aut^{x}, irl^{x}, swe^{x}	gbr^{x}	-
ECM validated	dnk^{+}	-	-
	bel^{-}, can^{-}, lux^{-}, esp^{-}	-	-
	-	-	-

$^{+}$ the impact of public debt ratio on economic growth is positive
$^{-}$ the impact of public debt ratio on economic growth is negative
^{x} the impact of public debt ratio on economic growth is not statistically significant

Note: the sign of the impact is approximated by the sum of all statistically significant coefficients of the public debt to GDP ratio variable.

In the remaining part of this section, we further qualify our results by analyzing the impact of other growth determinants, presenting some robustness test's results and discussing the causality issue that might happen in the debt-growth relationship.

5.1 Other growth determinants

Regarding the other growth determinants that are also included in the econometric specifications, the results illustrated in tables 3 and 4 indicate that the lag(s) of GDP per capita growth has a stabilizing effect, as it exhibits a negative impact on its contemporaneous value for all countries, except for Canada and Spain, where it is non-significant. The remaining growth determinants' results show that their coefficients have the expected sign and that government consumption as well as inflation seem to be the most influent variables on GDP per capita growth besides public debt ratio and the lagged value(s) of GDP per capita growth. The impact of government consumption on economic growth is negative and statistically significant for all the countries of the sample but two (Portugal and Spain). As explained by Barro (1991 / p.430), government consumption has "no direct effect on private productivity but lowers saving and growth through the distorting effects from taxation or government-expenditure programs". Gross fixed capital formation's influence is positive. It shows that domestic investment increases the productivity of capital and can generate new jobs, which is beneficial for economic growth.

However, this indicator is statistically significant only for Denmark and Spain. Regarding inflation, the results clearly indicate that it is harmful for the economy, confirming that a stable macroeconomic environment is important for economic growth. Openness to trade might increase the access to free markets, facilitate the transfer of technology and the diffusion of knowledge, and contribute to exploitation of comparative advantage. Thus this variable's impact on economic growth is positive. Regarding school enrollment ratio, it also has a positive impact on economic activity as education can bring, among others, higher income for individuals and also help to make investment more productive. This variable is statistically significant only for Portugal. Finally, population growth lowers income because the available capital must be spread over a larger population (see Mankiw et al. (1992)). However, as outlined by Headey and Hodge (2009 / p. 222), "the theoretical literature outlines both positive and negative effects of population growth"; for instance, a better educated working-age population growth might have positive effects on economic growth.

5.2 Robustness exercise

As robustness test, we perform the same analysis as in section 4.3 but this time we allow the coefficients of all the explanatory variables to vary across the two different regimes (see equations (7) and (8) above). Because of the low degree of freedom, it is important to note that these results must be taken with caution. They are reported in table D.5 in the Appendix and indicate that the threshold model is validated for only five countries (out of 17), which are Finland, Great Britain and Italy like in the basic set of specifications, and also Ireland and Spain. This implies that the relationship between public debt and GDP growth for the Netherlands is now linear (see table 3 above). Again, it can be concluded that the debt-value threshold is specific to each country; it ranges between 24,5% and 61,6%.

The results of the linear specification indicate that the contemporaneous value of public debt ratio has a negative impact on real GDP per capita growth in the Netherlands, which is also influenced by all the other growth determinants included in the specification, with the exception of population growth. The nonlinear estimations' results are reported in table D.6.in the Appendix and show that, in addition to be country-specific, the impact of public debt ratio on economic growth can also be different according to the regime and the lag(s) of the public debt ratio variable. Regarding Great Britain, the results are the same as the ones of the basic set of specifications. In Finland, public debt ratio has an impact on economic growth only in the upper regime suggesting that in this country, public debt ratio must be higher than 42,8% in order to have an influence on GDP per capita growth. In these two countries, the sign of the public debt ratio's variable changes according to its lags. In Spain, economic growth is influenced by the public debt ratio only in the lower regime and the link between these two variables is

negative. Regarding Ireland and Italy, the results indicate that the public debt ratio has no influence on economic growth.

The plots of the LR sequence against the estimated values of the threshold for Finland, Great Britain, Ireland, Italy and Spain are illustrated in the figure D.2 in the Appendix. In each case, the graphics show that estimated threshold's value lies in the "non rejection region". It can be observed that the confidence intervals are more precise for Finland, Great Britain and Italy than for Ireland and Spain.

Contrary to the basic set of specifications, the other growth determinants don't always have the expected sign (in particular for Spain). Again, this must be taken with caution because of the lower reliability of the results due to the low degree of freedom. For this reason, the discussion of the counter-intuitive results is reported to Appendix B. Nevertheless, it seems that that the variable that have the most important influence on economic activity is openness to trade in the upper regime. Furthermore, it can all the same be concluded that the link between public debt ratio and economic growth is country-specific, which confirms the findings of the basic set of specifications and further supports the fact that considering one country's own characteristics is important for governments to implement well-shaped policy measures.

5.3 Causality issue

This paper analyzes the impact of public debt ratio on economic growth and its possible nonlinearity. However, according to economic theory, economic growth might also have an influence on public debt ratio. Indeed, a decrease of economic growth might induce higher public debt in order to allow the government to stimulate economic activity through increased spending (see for example, Dube (2013), Lof and Malinen (2014) and Gomez-Puig and Sosvilla-Rivero (2015)). This statement raises the issue of causality between the two variables of interest. In Appendix C, a short literature survey summarizes the results of recent papers dealing with causality between economic growth and the public debt ratio. It emphasizes the fact that there might be causality between these two variables and that it may vary among countries and the considered period of time. This implies that there might be endogeneity in our empirical application, which would yield to biased estimates because of feedback effects. However, this problem is not relevant in our study because ARDL modeling allows to deal with it. Indeed, Pesaran and Shin (1997 / p. 16) in particular explain that "appropriate modification of the orders of the ARDL model is sufficient to simultaneously correct for the residual serial correlation and the problem of endogenous regressors". Thus, despite the fact that we don't test for causality in this study and even if

regressors in our econometric specifications might be endogenous, the ARDL methodology and, therefore, our results remain valid.

6. Summary

In this paper, the relationship between public debt GDP ratio and economic growth has been analyzed for 17 developed countries separately over the period 1970-2014. Several improvements have been provided in comparison with previous studies. In particular, we determined and tested for the debt-value threshold as well as analyzed the link between public debt and economic growth for each country individually. We also tested if the two variables of interest are cointegrated and we included additional growth determinants directly in the empirical setting. The results demonstrate that the relationship between public debt and growth as well as the debt-value threshold are country-specific. Indeed, they might depend on the institutional characteristics and the economic structure of the considered country, on the size of its public sector, on how and why public debt has been accumulated and/or on its composition. Several authors come to similar conclusions such as Rito Ribeiro et al. (2012) or Panizza and Presbitero (2013) for example.

Our empirical results offer an up-to-date confirmation of this heterogeneity across countries. They also illustrate which type of empirical issues need to be addressed to perform an in-depth analysis of the debt-growth relationship at the country level. The cointegration testing procedure showed that the ECM is validated for Belgium, Denmark, Finland, France, Greece, Ireland, Italy, Luxembourg, The Netherlands and Spain. The results indicate that the impact of public debt ratio on GDP growth might be positive, negative or null depending on the country and this variable's lagged values. Furthermore, the relationship between the two variables of interest is nonlinear for only four (out of 17) economies, which are Finland, Great Britain, Italy and the USA. Another result of this study is that the debt-value threshold also is country-specific, which further supports the fact that performing estimations for each country separately is crucial. This also implies that in different countries having a similar level of public debt, the impact of this variable on economic growth will not be necessarily the same in each country. Allowing the coefficients of all explanatory variables to vary across the two regime leads to similar conclusions.

In short, this study provides strong empirical support to the view that the relation between public debt and growth and the eventual debt threshold should be analyzed for each country individually. This has important policy implications; governments must take into account their own country’s characteristics while designing

fiscal policy measures aimed at, for example, stimulating growth or solving public debt problems. There is no universal recipe.

Although this paper has enlarged the number of country characteristics that deserve to be included in a thorough analysis, several possible improvements would be of interest in future work. The most important would be to use a methodology that would allow to simultaneously test long-run and short-run asymmetries. Longer time series would provide more accurate results and allow to test for an eventual second debt-to-GDP threshold's value and to estimate the same specifications for different sub-periods. The link between public debt and economic growth might also be clarified by taking into account different growth determinants, such as the quality of the institutions or the terms of trade for instance, as well as by considering various countries at different stages of development (not only industrialized economies). All these additional analyses should improve our understanding of the complex link between the public debt ratio and GDP per capita.

Appendix A: Data definitions

Exports of goods and services (current US$)

Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

GDP (current US$)

GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor calculated by the World Bank staff is used. In our sample, the countries for which there is a difference between the alternative conversion factor and the official exchange rate are the following: Austria, Belgium, Finland, France, Ireland, Italy, Luxembourg, Portugal, Spain and The Netherlands from 1970 to 1998 and Greece from 1970 to 2000. Sources: World Bank national accounts data, and OECD National Accounts data files.

GDP per capita (constant 2005 US$)

GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars. They exhibit the same growth rates as constant international U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

General government consolidated gross debt: Excessive deficit procedure (based on European System of Accounts (ESA) 2010) and former definition (linked series), percentage of GDP at market prices (excessive deficit procedure)

Government debt means the total gross debt at nominal value outstanding at the end of the year of the sector of general government, with the exception of those liabilities the corresponding financial assets of which are held

by the sector of general government. Government debt is constituted by the liabilities of general government in the following categories:

Currency and deposits, securities other than shares, excluding financial derivatives and loans as defined in ESA 1995. The nominal value of a liability outstanding at the end of the year is the face value. The nominal value of an index-linked liability corresponds to its face value adjusted by the index-related change in the value of the principal accrued to the end of the year.

Liabilities denominated in a foreign currency, or exchanged from one foreign currency through contractual agreements to one or more other foreign currencies shall be converted into the other foreign currencies at the rate agreed on in those contracts and shall be converted into the national currency on the basis of the representative market exchange rate prevailing on the last working day of each year.

Liabilities denominated in the national currency and exchanged through contractual agreements to a foreign currency shall be converted into the foreign currency at the rate agreed on in those contracts and shall be converted into the national currency on the basis of the representative market exchange rate prevailing on the last working day of each year.

Liabilities denominated in a foreign currency and exchanged through contractual agreements to the national currency shall be converted into the national currency at the rate agreed on in those contracts.

Source: Eurostat (the Statistical Office of the European Commission).

General government final consumption expenditure (% of GDP)

General government final consumption expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation. Sources: World Bank national accounts data, and OECD National Accounts data files.

Gross fixed capital formation (% of GDP)

Gross fixed capital formation (formerly gross domestic fixed investment) is used as proxy for domestic investment. It includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of

valuables are also considered capital formation. Sources: World Bank national accounts data, and OECD National Accounts data files.

Imports of goods and services (current US$)

Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

Inflation, GDP deflator (annual %)

Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency. Sources: World Bank national accounts data, and OECD National Accounts data files.

School enrollment, secondary (% gross)

Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Secondary education completes the provision of basic education that began at the primary level, and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers. Sources: UNESCO Institute for Statistics.

Population growth (annual %)

Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of the country of origin. Sources: (1) United Nations Population Division. World Population Prospects, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.

Appendix B: Robustness test's results discussion

According to the results presented in table D.6, the sign of the openness to trade's coefficient is not the same for each country. As explained in Kaplinsky et al. (2007), openness to trade's net effect is ambiguous as its impacts can be either positive (when trade is complementary) or negative (when more competition is created). Thus, some of the analyzed countries might have been more vulnerable than others to openness to trade, which would explain the negative sign of this variable's coefficient in Finland and in Spain in the upper regime. In Spain, when the public debt ratio is above its threshold value, the results show that the impact of government consumption is positive for economic growth. This might be the case, for example, when governments use public expenditure in an efficient way or in order to finance facilities that are not offered by the private economy, such as in the public health sector for example (see Musaba et al. (2013)). The results also indicate that gross fixed capital formation has a negative impact on economic growth in the lower regime in Spain and in the upper one in Great Britain, which is counterintuitive. However, according to the findings of Cheung et al. (2012), this might happen. These authors explain that, as countries become richer, the link between investment and growth weaken over time because of diminishing marginal returns to capital. In richer countries, marginal returns to investment might be close to zero or even negative, which might explain why, in some richer countries, investment might have a negative effect on growth. The negative impact of education on economic growth, which can be observed in Great Britain and in Spain in the upper regime, might be due to the fact that education is of low quality (see Pritchett (2001)) or because there is no appropriate match between the educational qualification and the current demand for labor (see Vijesandiran and Vinayagathasan (2015)).

Appendix C: Causality issue - short literature survey

Ferreira (2009) analyzes 20 OECD between 1988 and 2001 and finds that there is bi-directional Granger-causality between growth of real GDP per capita and public debt ratio. In order to study whether public debt has a causal effect on economic growth, Panizza and Presbitero (2014) consider 17 OECD countries over the 1981 to 2008 period. They use an instrumental variable approach and find that there is no evidence that public debt has a causal effect on economic growth. On the basis of the data used by Reinhart and Rogoff (2010a), and later Herndon et al. (2014), Bell et al. (2015) study the relationship between growth and debt in developed countries. Regarding causality, the authors developed a new method extending distributed lag models to multilevel situations. Their results, shown as impulse responses, suggest that the causal direction is predominantly from growth-to-debt, and is consistent (with some exceptions) across countries. Gomez-Puig and Sosvilla-Rivero

(2015) performed Granger-causality and endogenous breakpoint tests for 11 countries of the European Economic and Monetary Union separately over the 1980 to 2013 period. Their results show that causality between (changes in) public debt and economic growth vary among countries. By means of a panel bootstrap Granger-causality test and controlling for both the presence of cross-country heterogeneity and cross-sectional dependence, Puente-Ajovin and Sanso-Navarro (2015) analyze the possible causal relationship between debt and growth in 16 OECD countries from 1980 to 2009. The authors find that there is no Granger-causal effect of government debt on growth but that growth Granger-causes debt. Indeed, low economic growth leads to high levels of public debt. Ferreira (2016) uses panel Granger-causality estimations in order to study whether there is Granger-causality between real GDP growth and the growth of three debt categories: public, foreign and private debt. He considers 28 European Union countries over the 2001-2012 period. Regarding public debt, the author finds bidirectional causality between public debt and economic growth: economic growth Granger-causes a decrease in public debt and causality running from public debt to economic growth is positive.

Appendix D: Tables and Figures

Table D.1: Data summary

Austria

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	30129	7718	16780	41230
General government consolidated gross debt (percentage of GDP)	45	53.6	20.3	16.7	84.2
General government final consumption expenditure (% of GDP)	45	18.2	1.6	14.1	20.6
Gross fixed capital formation (percentage of GDP)	45	25.4	2.4	21.6	32.0
Openness to trade	45	0.8	0.2	0.5	1.1
Inflation, GDP deflator (annual %)	38	2.9	1.7	0.3	6.7
School enrollment, secondary (% gross)	43	97.4	5.3	88.8	107.0
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.88E+11	1.35E+11	1.53E+10	4.37E+11
Exports of goods and services (current US$)	45	8.23E+10	7.41E+10	4.21E+09	2.33E+11
Imports of goods and services (current US$)	45	7.93E+10	6.85E+10	4.22E+09	2.19E+11

Belgium

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	29130	6785	17257	38636
General government consolidated gross debt (percentage of GDP)	45	98.7	25.2	54.4	134.4
General government final consumption expenditure (% of GDP)	45	21.6	1.8	16.7	24.4
Gross fixed capital formation (percentage of GDP)	45	22.6	2.3	18.5	27.0
Openness to trade	45	1.2	0.2	0.8	1.7
Inflation, GDP deflator (annual %)	45	3.7	2.8	0.4	12.9
School enrollment, secondary (% gross)	43	111.2	25.3	80.8	163.1
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	2.35E+11	1.60E+11	2.68E+10	5.32E+11
Exports of goods and services (current US$)	45	1.62E+11	1.34E+11	1.19E+10	4.46E+11
Imports of goods and services (current US$)	45	1.57E+11	1.31E+11	1.14E+10	4.42E+11

Canada

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28898	5892	18798	38255
General government consolidated gross debt (percentage of GDP)	40	68.3	17.8	42.9	99.7
General government final consumption expenditure (% of GDP)	45	21.2	1.3	19.0	24.4
Gross fixed capital formation (percentage of GDP)	45	22.0	1.7	18.5	25.1
Openness to trade	45	0.6	0.1	0.4	0.8
Inflation, GDP deflator (annual %)	45	4.4	3.5	-2.1	15.2
School enrollment, secondary (% gross)	42	98.7	5.7	87.1	110.3
Population growth (annual %)	44	0.01	0.00	0.01	0.02
Nominal GDP (current US dollars)	45	6.98E+11	5.29E+11	8.78E+10	1.84E+12
Exports of goods and services (current US$)	45	2.24E+11	1.78E+11	1.93E+10	5.64E+11
Imports of goods and services (current US$)	45	2.17E+11	1.78E+11	1.70E+10	5.87E+11

Denmark

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	38559	8265	25145	50695
General government consolidated gross debt (percentage of GDP)	44	47.3	21.6	6.2	80.5
General government final consumption expenditure (% of GDP)	45	24.4	1.8	19.4	28.1
Gross fixed capital formation (percentage of GDP)	45	21.4	2.7	17.5	27.2
Openness to trade	45	0.7	0.1	0.5	1.0
Inflation, GDP deflator (annual %)	45	4.7	3.7	0.5	13.3
School enrollment, secondary (% gross)	43	111.7	11.7	93.0	131.0
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.55E+11	1.06E+11	1.69E+10	3.53E+11
Exports of goods and services (current US$)	45	6.84E+10	5.88E+10	4.61E+09	1.90E+11
Imports of goods and services (current US$)	45	6.16E+10	5.27E+10	5.10E+09	1.78E+11

Finland

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28836	8168	15787	42415
General government consolidated gross debt (percentage of GDP)	45	29.6	18.2	6.1	59.3
General government final consumption expenditure (% of GDP)	45	20.2	2.8	14.3	24.8
Gross fixed capital formation (percentage of GDP)	45	25.0	3.7	18.6	33.5
Openness to trade	45	0.6	0.1	0.4	0.9
Inflation, GDP deflator (annual %)	45	5.2	4.7	-0.1	22.1
School enrollment, secondary (% gross)	43	110.5	10.8	88.6	143.2
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.22E+11	8.45E+10	1.14E+10	2.84E+11
Exports of goods and services (current US$)	45	4.37E+10	3.64E+10	2.71E+09	1.28E+11
Imports of goods and services (current US$)	45	4.03E+10	3.46E+10	2.90E+09	1.18E+11

France

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28271	5886	17381	36074
General government consolidated gross debt (percentage of GDP)	38	51.3	22.3	20.1	95.6
General government final consumption expenditure (% of GDP)	45	21.7	1.9	16.9	24.2
Gross fixed capital formation (percentage of GDP)	45	22.5	1.8	19.4	26.8
Openness to trade	45	0.5	0.1	0.3	0.6
Inflation, GDP deflator (annual %)	45	4.5	4.0	0.1	13.8
School enrollment, secondary (% gross)	43	98.8	13.0	74.3	114.2
Population growth (annual %)	44	0.01	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.33E+12	8.72E+11	1.49E+11	2.92E+12
Exports of goods and services (current US$)	45	3.32E+11	2.50E+11	2.35E+10	8.12E+11
Imports of goods and services (current US$)	45	3.36E+11	2.66E+11	2.28E+10	8.69E+11

Great Britain

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	29704	8056	17781	41544
General government consolidated gross debt (percentage of GDP)	44	52.0	15.0	31.3	88.2
General government final consumption expenditure (% of GDP)	45	19.4	1.5	16.8	22.3
Gross fixed capital formation (percentage of GDP)	45	20.0	2.5	16.0	24.9
Openness to trade	45	0.5	0.1	0.4	0.6
Inflation, GDP deflator (annual %)	45	6.2	5.5	0.3	25.9
School enrollment, secondary (% gross)	42	91.0	9.6	76.6	105.4
Population growth (annual %)	42	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.26E+12	9.12E+11	1.31E+11	2.99E+12
Exports of goods and services (current US$)	45	3.33E+11	2.59E+11	2.79E+10	8.48E+11
Imports of goods and services (current US$)	45	3.54E+11	2.84E+11	2.67E+10	9.05E+11

Greece

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	17142	3429	10904	24470
General government consolidated gross debt (percentage of GDP)	45	76.8	47.7	15.9	178.6
General government final consumption expenditure (% of GDP)	45	17.6	2.7	11.1	23.3
Gross fixed capital formation (percentage of GDP)	45	24.0	5.2	11.6	35.4
Openness to trade	45	0.4	0.1	0.2	0.7
Inflation, GDP deflator (annual %)	43	10.7	8.3	-2.5	27.2
School enrollment, secondary (% gross)	41	89.3	10.4	63.3	108.2
Population growth (annual %)	42	0.00	0.00	-0.01	0.02
Nominal GDP (current US dollars)	45	1.29E+11	9.86E+10	1.31E+10	3.54E+11
Exports of goods and services (current US$)	45	2.67E+10	2.52E+10	1.04E+09	8.28E+10
Imports of goods and services (current US$)	45	3.76E+10	3.39E+10	2.00E+09	1.27E+11

Ireland

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	29915	15029	12041	53918
General government consolidated gross debt (percentage of GDP)	45	68.6	28.6	23.6	120.2
General government final consumption expenditure (% of GDP)	45	18.2	2.0	14.7	22.2
Gross fixed capital formation (percentage of GDP)	45	22.4	4.2	15.9	31.0
Openness to trade	45	1.3	0.4	0.7	2.1
Inflation, GDP deflator (annual %)	44	6.0	6.1	-4.3	21.0
School enrollment, secondary (% gross)	43	100.5	12.8	73.3	126.5
Population growth (annual %)	44	0.01	0.01	0.00	0.03
Nominal GDP (current US dollars)	45	9.19E+10	9.05E+10	4.40E+09	2.75E+11
Exports of goods and services (current US$)	45	7.87E+10	8.96E+10	1.45E+09	2.85E+11
Imports of goods and services (current US$)	45	6.78E+10	7.55E+10	1.82E+09	2.39E+11

Italy

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	25556	5527	15156	32831
General government consolidated gross debt (percentage of GDP)	45	87.9	27.3	35.7	132.3
General government final consumption expenditure (% of GDP)	45	18.2	1.4	15.1	20.6
Gross fixed capital formation (percentage of GDP)	45	21.7	2.5	16.6	26.8
Openness to trade	45	0.4	0.1	0.3	0.6
Inflation, GDP deflator (annual %)	45	7.4	6.2	0.3	20.8
School enrollment, secondary (% gross)	43	83.9	13.0	59.9	102.7
Population growth (annual %)	41	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.08E+12	7.17E+11	1.13E+11	2.39E+12
Exports of goods and services (current US$)	45	2.58E+11	2.00E+11	1.72E+10	6.45E+11
Imports of goods and services (current US$)	45	2.50E+11	1.99E+11	1.69E+10	6.64E+11

Japan

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28642	7404	15162	37595
General government consolidated gross debt (percentage of GDP)	45	106.5	71.7	11.5	245.8
General government final consumption expenditure (% of GDP)	45	15.6	2.7	10.7	20.6
Gross fixed capital formation (percentage of GDP)	45	27.6	4.5	20.0	36.4
Openness to trade	45	0.2	0.1	0.2	0.4
Inflation, GDP deflator (annual %)	45	2.3	5.3	-2.2	22.7
School enrollment, secondary (% gross)	42	97.3	4.4	86.5	102.7
Population growth (annual %)	44	0.00	0.00	0.00	0.02
Nominal GDP (current US dollars)	45	3.06E+12	1.87E+12	2.09E+11	5.95E+12
Exports of goods and services (current US$)	45	3.84E+11	2.68E+11	2.21E+10	8.93E+11
Imports of goods and services (current US$)	45	3.58E+11	2.82E+11	1.96E+10	9.92E+11

Luxembourg

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	55052	20801	27550	87773
General government consolidated gross debt (percentage of GDP)	44	10.9	5.3	4.2	23.4
General government final consumption expenditure (% of GDP)	45	15.0	1.6	10.1	17.1
Gross fixed capital formation (percentage of GDP)	45	20.3	1.8	14.4	23.1
Openness to trade	44	2.3	0.7	1.5	3.7
Inflation, GDP deflator (annual %)	45	4.3	4.6	-1.9	21.3
School enrollment, secondary (% gross)	43	79.1	17.1	47.3	102.4
Population growth (annual %)	44	0.01	0.01	0.00	0.02
Nominal GDP (current US dollars)	45	2.09E+10	1.93E+10	1.52E+09	6.49E+10
Exports of goods and services (current US$)	45	3.25E+10	3.82E+10	1.37E+09	1.32E+11
Imports of goods and services (current US$)	45	2.70E+10	3.19E+10	1.02E+09	1.11E+11

Portugal

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	14285	3998	7487	19489
General government consolidated gross debt (percentage of GDP)	42	57.2	27.8	13.3	130.2
General government final consumption expenditure (% of GDP)	45	16.2	3.3	11.2	21.4
Gross fixed capital formation (percentage of GDP)	44	25.2	4.2	14.8	33.2
Openness to trade	45	0.6	0.1	0.4	0.8
Inflation, GDP deflator (annual %)	45	9.5	8.1	-0.4	26.4
School enrollment, secondary (% gross)	42	78.4	25.2	37.5	109.0
Population growth (annual %)	44	0.00	0.01	-0.01	0.04
Nominal GDP (current US dollars)	45	1.04E+11	8.25E+10	8.11E+09	2.62E+11
Exports of goods and services (current US$)	45	3.04E+10	2.80E+10	1.55E+09	9.21E+10
Imports of goods and services (current US$)	45	3.74E+10	3.20E+10	1.95E+09	1.07E+11

Spain

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	19809	5102	11541	27661
General government consolidated gross debt (percentage of GDP)	45	41.9	22.6	11.5	99.3
General government final consumption expenditure (% of GDP)	45	15.8	3.0	9.9	20.5
Gross fixed capital formation (percentage of GDP)	45	24.4	3.1	19.2	31.1
Openness to trade	45	0.4	0.1	0.3	0.6
Inflation, GDP deflator (annual %)	45	7.3	5.8	-0.4	23.4
School enrollment, secondary (% gross)	43	99.9	20.9	53.8	131.1
Population growth (annual %)	44	0.01	0.01	0.00	0.02
Nominal GDP (current US dollars)	45	6.09E+11	4.94E+11	4.09E+10	1.63E+12
Exports of goods and services (current US$)	45	1.49E+11	1.44E+11	4.98E+09	4.50E+11
Imports of goods and services (current US$)	45	1.60E+11	1.52E+11	5.58E+09	4.98E+11

Sweden

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	33686	7689	22806	46037
General government consolidated gross debt (percentage of GDP)	45	45.5	14.0	23.6	70.3
General government final consumption expenditure (% of GDP)	45	25.1	1.7	20.3	27.6
Gross fixed capital formation (percentage of GDP)	45	23.9	2.7	19.2	29.2
Openness to trade	45	0.7	0.1	0.4	0.9
Inflation, GDP deflator (annual %)	45	5.1	4.0	0.4	14.5
School enrollment, secondary (% gross)	43	103.9	24.2	76.9	156.6
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	2.50E+11	1.60E+11	3.76E+10	5.79E+11
Exports of goods and services (current US$)	45	9.97E+10	8.08E+10	8.49E+09	2.63E+11
Imports of goods and services (current US$)	45	8.83E+10	7.02E+10	8.45E+09	2.36E+11

The Netherlands

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	32829	7857	21061	45043
General government consolidated gross debt (percentage of GDP)	40	58.3	12.4	38.4	75.5
General government final consumption expenditure (% of GDP)	45	22.4	1.9	18.2	26.5
Gross fixed capital formation (percentage of GDP)	45	22.3	2.2	17.9	29.1
Openness to trade	45	1.1	0.2	0.8	1.5
Inflation, GDP deflator (annual %)	45	3.5	3.3	-1.0	13.2
School enrollment, secondary (% gross)	43	112.1	18.4	75.5	141.6
Population growth (annual %)	43	0.01	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	3.92E+11	2.81E+11	3.77E+10	9.36E+11
Exports of goods and services (current US$)	45	2.54E+11	2.20E+11	1.64E+10	7.29E+11
Imports of goods and services (current US$)	45	2.26E+11	1.92E+11	1.64E+10	6.29E+11

USA

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	34113	8232	21183	46405
General government consolidated gross debt (percentage of GDP)	45	61.0	18.1	40.2	104.8
General government final consumption expenditure (% of GDP)	45	15.8	1.0	14.0	18.1
Gross fixed capital formation (percentage of GDP)	45	21.6	1.6	18.0	24.4
Openness to trade	45	0.2	0.1	0.1	0.3
Inflation, GDP deflator (annual %)	45	3.6	2.4	0.8	9.3
School enrollment, secondary (% gross)	43	92.1	4.4	78.6	96.5
Population growth (annual %)	44	0.01	0.00	0.01	0.01
Nominal GDP (current US dollars)	45	7.60E+12	5.09E+12	1.08E+12	1.74E+13
Exports of goods and services (current US$)	45	8.09E+11	6.71E+11	5.97E+10	2.34E+12
Imports of goods and services (current US$)	45	1.03E+12	8.98E+11	5.58E+10	2.87E+12

Table D.2: Augmented Dickey-Fuller test

	Country							
Variable	**Austria**	**Belgium**	**Canada**	**Denmark**	**Finland**	**France**	**Great Britain**	**Greece**
Public debt ratio (% GDP)								
ADF statistic								
series in levels	-1.306	-2.864*	-3.210*[a]	-2.481	-2.716	-2.643	0.241	-1.539
series in first-difference	-5.420***	-	-2.241**	-2.821***	-3.174***	-3.680***	-2.882***	-6.102***
constant ≠ 0	Yes	Yes	No	No	No	Yes	No	Yes
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	1	3	0	0	3	0	0	0
Real GDP per capita growth								
ADF statistic								
series in levels	-5.729***[a]	-6.679***[a]	-4.710***	-5.386***[a]	-3.773***	-5.294***[a]	-4.710***	-3.798***
series in first-difference	-5.084***	-7.516***	-	-5.902***	-	-5.266***	-	-
constant ≠ 0	No	No	Yes	No	Yes	No	Yes	No
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	4	1	0	4	0	4	1	0
General government final consumption expenditure (% of GDP)								
ADF statistic								
series in levels	-2.990	-2.807	-2.576	-2.494	-1.488	-3.495*[a]	-2.929**	-1.713
series in first-difference	-4.548***	-5.204***	-4.985***	-5.515***	-5.306***	-4.607***	-	-7.307***
constant ≠ 0	No	No	No	No	No	No	Yes	No
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	1	0	0	0	1	0	1	0
Gross fixed capital formation (% of GDP)								
ADF statistic								
series in levels	-4.297***[a]	-2.253	-2.068	-2.541	-3.479*[a]	-2.352	-4.688***[a]	-2.297
series in first-difference	-6.743***	-4.907***	-5.304***	-4.297***	-3.755***	-4.171***	-4.382***	-5.581***
constant ≠ 0	No	No	No	No	No	No	Yes	No
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	0	0	0	4	1	0	6	0
Population (total) growth								
ADF statistic								
series in levels	-4.217***[a]	-0.933	-3.460*[a]	-3.423*[a]	-4.547***	-2.667*	2.091	-3.828**[a]
series in first-difference	-3.990***	-6.787***	-6.523***	-1.982**	-	-	-3.874***	-5.051***
constant ≠ 0	No	No	No	No	Yes	Yes	Yes	No
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	3	0	0	5	2	0	7	1
Openness to trade								
ADF statistic								
series in levels	-2.666	-3.161	-1.729	-2.363	-2.284	-3.02694	-2.350689	-3.139
series in first-difference	-5.609***	-6.221***	-4.569***	-5.113***	-6.441***	-5.791***	-6.894***	-5.578***
constant ≠ 0	Yes	Yes	No	Yes	No	Yes	No	Yes
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	2	0	0	2	0	1	0	1
GDP deflator								
ADF statistic								
series in levels	-2.572197	-4.517***	-1.911*	-2.588**	-4.520***	-2.344	-2.371**	-2.219
series in first-difference	-4.243***	-	-	-	-	-4.920***	-	-9.285***
constant ≠ 0	No	No	No	No	No	No	No	No
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	1	6	8	8	6	0	8	0
School enrollment, secondary (% gross)								
ADF statistic								
series in levels	-1.639463	0.643	-2.495011	-3.256*[a]	-2.286684	-1.924577	-1.665	-2.641*
series in first-difference	-5.004***	-4.742***	-1.727*	-1.628*	-4.290***	-4.893***	-4.914***	-
constant ≠ 0	No	No	No	No	No	Yes	No	Yes
trend ≠ 0	No	No	No	No	No	No	No	No
numer of lags (p)	0	0	0	1	0	0	0	0

Notes: The null hypothesis is that the series has an unit root.

p is the order of the augmentation needed to eliminate any autocorrelation in the residuals of the ADF regression.

*/ **/ *** indicate significance at 10%/ 5%/ 1% on the basis of the critical values by MacKinnon (1991).

[a]the series in levels is a trend stationary processus

Table D.2: Augmented Dickey-Fuller test (continued)

	Country								
Variable	**Ireland**	**Italy**	**Japan**	**Luxembourg**	**Portugal**	**Spain**	**Sweden**	**The Netherlands**	**United States**
Public debt ratio (% GDP)									
ADF statistic									
series in levels	-3.362**	-2.496	0.850	0.255	1.622	-4.343***[a]	-2.532	-3.604**	-3.968**[a]
series in first-difference	-	-3.688***	-3.693***	-2.934***	-3.472**	-2.792***	-2.982***	-	-2.727***
constant $\neq 0$	Yes	Yes	Yes	No	Yes	No	No	Yes	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	1	0	0	1	0	4	0	7	0
Real GDP per capita growth									
ADF statistic									
series in levels	-3.160**	-5.778***[a]	-5.729***[a]	-4.994***	-1.373	-2.316**	-4.851***	-2.891***	-4.799***
series in first-difference	-	-9.053***	-8.154***	-	-5.197***	-	-	-	-
constant $\neq 0$	Yes	No	No	Yes	No	No	Yes	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	0	1	1	0	6	0	0	0	0
General government final consumption expenditure (% of GDP)									
ADF statistic									
series in levels	-2.346	-2.353	-1.703	-2.990**	1.315	-2.674	-5.128***	-4.041	-2.772*
series in first-difference	-5.524***	-6.055***	-4.874***	-	-5.566***	-4.041***	-	-5.449***	-
constant $\neq 0$	No	No	Yes	Yes	No	Yes	Yes	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	1	0	0	0	0	2	6	0	1
Gross fixed capital formation (% of GDP)									
ADF statistic									
series in levels	-3.921***	-2.590	-3.160	-3.851***	-3.182	-2.741*	-2.523	-2.060	-3.796**[a]
series in first-difference	-	-4.537***	-4.425***	-	-4.116***	-	-4.332***	-1.831*	-4.626***
constant $\neq 0$	Yes	No	No	Yes	No	Yes	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	9	0	1	0	2	1	0	7	2
Population (total) growth									
ADF statistic									
series in levels	-3.174**	-5.554***	-4.932***[a]	-4.355***[a]	-6.413***	-2.826*[a]	-2.333	-2.247	-1.952
series in first-difference	-	-	-9.533***	-2.888*	-	-2.684***	-2.723***	-2.419**	-4.428***
constant $\neq 0$	Yes	No	Yes	Yes	No	No	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	9	9	1	9	4	5	2	9	2
Openness to trade									
ADF statistic									
series in levels	-2.833	-2.060	0.747	-1.520	-3.256*[a]	-2.866	-2.580	-2.450	-3.385*[a]
series in first-difference	-5.782***	-2.369**	-6.133***	-6.018***	-6.277***	-5.315***	-6.511***	-6.409***	-6.061***
constant $\neq 0$	Yes	No	No	Yes	No	No	No	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	0	8	0	0	0	0	0	0	1
GDP deflator									
ADF statistic									
series in levels	-3.703**[a]	-2.468	-2.732***	-8.437***[a]	-3.024	-2.696	-3.443*[a]	-3.015***	-2.004**
series in first-difference	-8.153***	-6.306***	-	-5.846***	-2.172**	-5.981***	-7.480***		-
constant $\neq 0$	No	Yes	No	No	No	No	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	0	3	6	4	5	0	0	0	7
School enrollment, secondary (% gross)									
ADF statistic									
series in levels	-3.058	-3.303*[a]	-2.995**	-4.360***[a]	1.193	-2.918	-4.386***[a]	-1.818	-1.836
series in first-difference	-4.270***	-4.353***	-	-5.060***	-4.192***	-4.500***	-4.491***	-4.960***	-3.924***
constant $\neq 0$	Yes	Yes	Yes	Yes	No	Yes	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	4	0	0	0	0	1	0	0	2

Notes: The null hypothesis is that the series has an unit root.

p is the order of the augmentation needed to eliminate any autocorrelation in the residuals of the ADF regression.

*/ **/ *** indicate significance at 10%/ 5%/ 1% on the basis of the critical values by MacKinnon (1991).

[a]the series in levels is a trend stationary processus

Table D.3: Optimal number of lags, Breusch-Godfrey serial correlation LM test and ARDL bounds test

	Optimal number of lags		**Breusch-Godfrey serial correlation LM test[1]**		**ARDL bounds test[2]**
Country	Real GDP per capita growth	Public debt ratio (% GDP)	F-stat	Prob	F-statistic
Austria	1	0	0.622565	0.6101	9.809349***
Belgium	1	0	1.389372	0.2736	8.065755***
Canada	1	0	1.868461	0.1732	7.087152***
Denmark	1	1	2.237459	0.1153	20.20461***
Finland	1	2	1.082378	0.3804	18.57559***
France	1	1	1.950517	0.1766	20.58465***
Great Britain	1	1	1.316591	0.2998	18.81013***
Greece	1	2	0.665753	0.5860	4.851426**
Ireland[3]	4	2	1.427348	0.2797	3.330997
Italy	1	1	1.9827	0.1548	36.87924***
Japan	2	0	0.468061	0.7084	37.55937***
Luxembourg	2	1	1.478318	0.2540	8.430628***
Portugal	1	1	1.4035	0.2761	8.831281***
Spain	1	0	0.649825	0.5918	6.857118***
Sweden	2	0	2.29873	0.1101	16.91255***
The Netherlands	2	1	1.595988	0.2321	7.403496***
United States	1	0	2.308088	0.1059	28.22112***

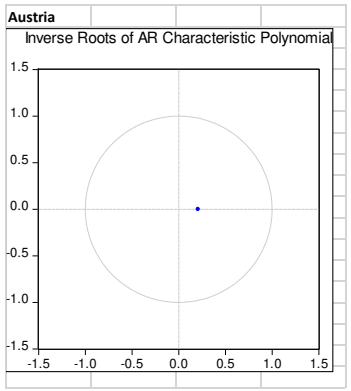
[1] H_0: there is no serial correlation up to lag order p, where p is a pre-specified integer (here: p=3)

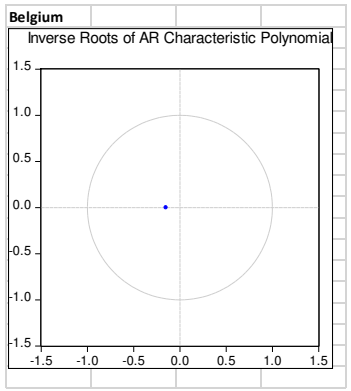
[2] H_0: no long-run relationships exists / Exact critical values by Narayan (2005) (here: k=7, where k+1 is the number of variables)

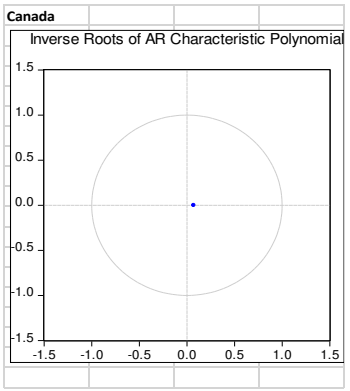
***, ** and * indicate that H_0 is rejected at the 1%, 5% and 10% significance level respectively

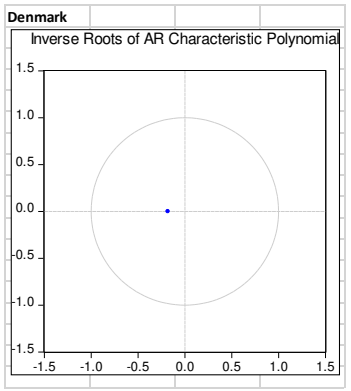
[3] for Ireland, we let the number of lags be up to 4. Otherwise, it is not possible to get a specification with no serial error correlation and which is stable.

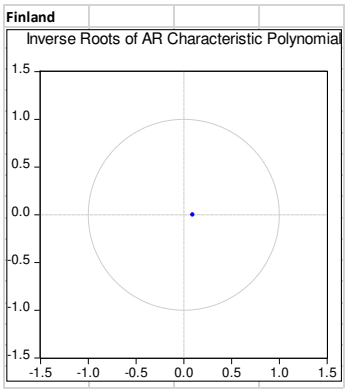
Table D.4: Stability test

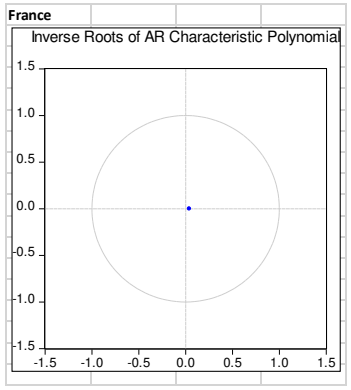


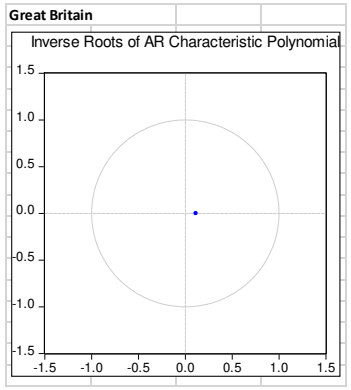


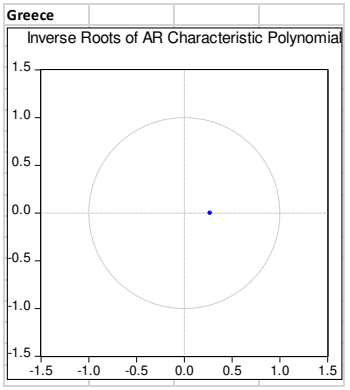












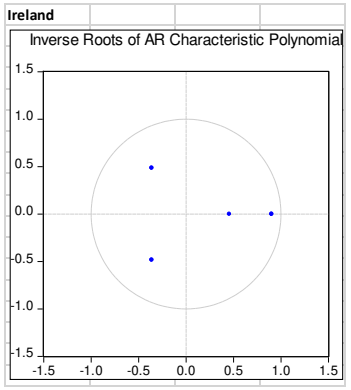
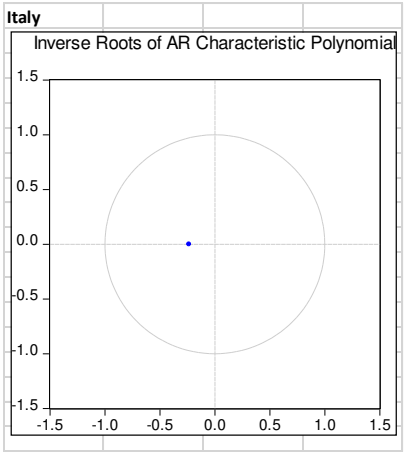
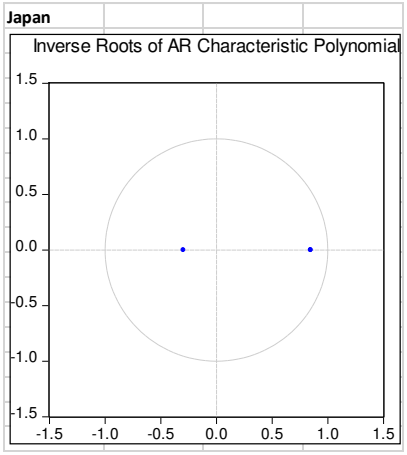


Table D.4: Stability test (continued)

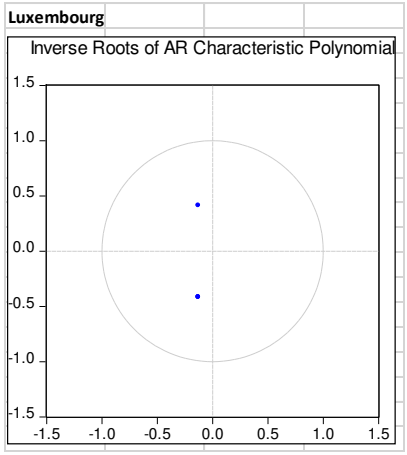
Italy



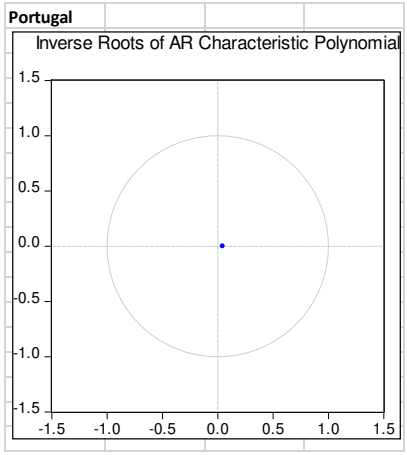
Japan



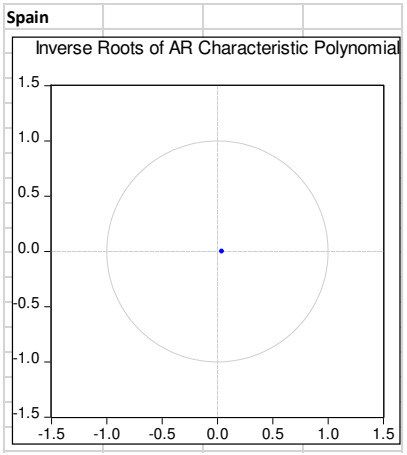
Luxembourg



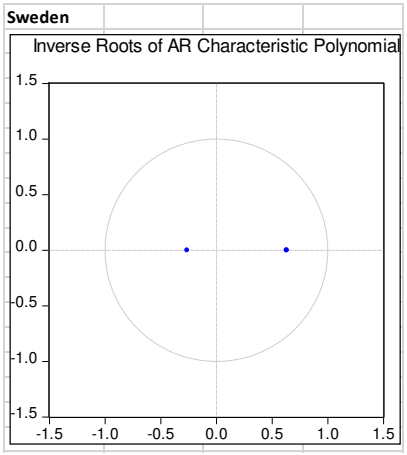
Portugal



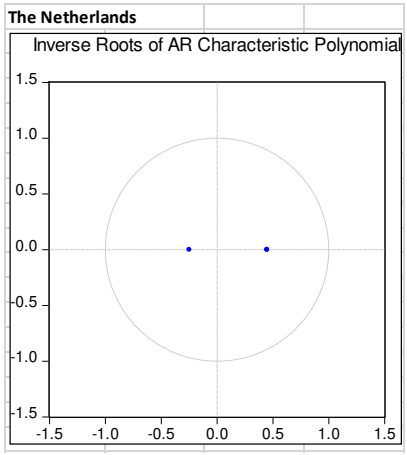
Spain



Sweden



The Netherlands



USA

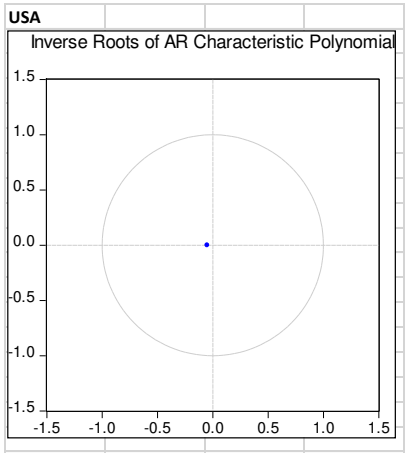


Table D.5: Threshold that minimizes SSR, F statistic and bootstrap p-value

Countries	**Threshold of public debt ratio (% GDP) that minimizes SSR**	**F Statistic**	**Bootstrap p-value**[1]
Austria	47.9	42.2	0.533
Belgium	94.6	38.3	0.397
Canada	74.7	32.0	0.369
Denmark	61.8	26.5	0.616
Finland	**42.8**	**104.9**	**0.033**
France	61.1	36.3	0.353
Great Britain	**51.2**	**87.5**	**0.044**
Greece	48.8	46.6	0.722
Ireland	**61.6**	**220.0**	**0.038**
Italy	**57.2**	**108.2**	**0.024**
Japan	169.6	54.2	0.141
Luxembourg	6.4	41.4	0.713
Portugal	56.0	52.4	0.258
Spain	**24.5**	**84.6**	**0.077**
Sweden	39.8	28.4	0.826
The Netherlands	51.4	67.9	0.144
USA	53.0	33.7	0.710

[1] Generated on the basis of Hansen's (1996) procedure

Table D.6: Specifications with threshold

Dependent variable: Real GDP per capita growth (in first-differences)

	Finland	Great Britain	Ireland	Italy	Spain
Real GDP per capita growth (-1) (if Public debt ratio ≤threshold)	-0.132	0.007	2.222	-0.503	-0.006
	0.379	*0.974*	*0.252*	*0.119*	*0.948*
Real GDP per capita growth (-1) (if Public debt ratio>threshold)	-2.947	-1.177	-3.021	0.326	0.013
	*0.000****	*0.000****	*0.131*	*0.353*	*0.921*
Real GDP per capita growth (-2) (if Public debt ratio ≤threshold)			1.241		
			0.121		
Real GDP per capita growth (-2) (if Public debt ratio>threshold)			-2.253		
			*0.013***		
Real GDP per capita growth (-3) (if Public debt ratio ≤threshold)			-2.425		
			0.332		
Real GDP per capita growth (-3) (if Public debt ratio>threshold)			1.934		
			0.436		
Real GDP per capita growth (-4) (if Public debt ratio ≤threshold)			-2.755		
			0.239		
Real GDP per capita growth (-4) (if Public debt ratio>threshold)			2.315		
			0.318		
Public debt ratio (if Public debt ratio ≤threshold)	-0.075	0.076	0.951	-1.331	-0.56
	0.616	*0.482*	*0.383*	*0.159*	*0.009****
Public debt ratio (if Public debt ratio>threshold)	18.101	-0.645	-1.058	0.767	0.313
	*0.000****	*0.000****	*0.335*	*0.392*	*0.135*
Public debt ratio(-1) (if Public debt ratio ≤threshold)	0.441	0.078	-0.195	1.436	
	0.109	*0.53*	*0.695*	*0.227*	
Public debt ratio(-1) (if Public debt ratio>threshold)	-3.526	0.321	0.191	-0.974	
	*0.000****	*0.019***	*0.707*	*0.425*	
Public debt ratio(-2) (if Public debt ratio ≤threshold)	-0.075		-1.022		
	0.661		*0.16*		
Public debt ratio(-2) (if Public debt ratio>threshold)	3.107		1.159		
	*0.000****		*0.118*		
ECT(-1) (if Public debt ratio ≤threshold)					-0.976
					*0.002****
ECT(-1) (if Public debt ratio>threshold)					0.234
					0.447
Government consumption (if Public debt ratio ≤threshold)	-2.977	-0.74	-17.163	0.063	-10.626
	*0.000****	*0.292*	*0.252*	*0.976*	*0.010****
Government consumption (if Public debt ratio>threshold)	-110.892	-1.176	16.489	1.099	9.948
	*0.000****	*0.108*	*0.27*	*0.647*	*0.015***
Gross fixed capital formation (if Public debt ratio ≤threshold)	0.031	0.407	*-2.342*	6.353	-2.093
	0.798	*0.319*	0.411	*0.236*	*0.070**
Gross fixed capital formation (if Public debt ratio>threshold)	48.977	-1.548	2.959	-6.849	2.691
	*0.000****	*0.003****	*0.305*	*0.208*	*0.024***
Openness to trade (if Public debt ratio ≤threshold)	9.499	3.823	-58.625	-29.097	169.337
	*0.072**	*0.795*	*0.303*	*0.329*	*0.012***
Openness to trade (if Public debt ratio>threshold)	-1.179	48.748	61.348	55.938	-167.842
	*0.000****	*0.004****	*0.285*	*0.081**	*0.013***
GDP deflator (if Public debt ratio ≤threshold)	-0.468	-0.425	0.096	-1.820	-0.233
	*0.000****	*0.065**	*0.922*	*0.031***	*0.145*
GDP deflator (if Public debt ratio>threshold)	-7.677	0.089	-0.268	1.185	-0.084
	*0.000****	*0.689*	*0.785*	*0.157*	*0.674*
School enrollment (if Public debt ratio ≤threshold)	-0.024	0.068	-1.123	2.147	0.686
	0.567	*0.437*	*0.38*	*0.115*	*0.033***
School enrollment (if Public debt rati>threshold)	1.659	-0.353	0.530	-1.915	-0.699
	*0.000****	*0.001****	*0.677*	*0.127*	*0.031***
Population growth (if Public debt ratio ≤threshold)	-494.077	-93.519	-821.043	0.000	419.046
	0.134	*0.917*	*0.367*	*1*	*0.203*
Population growth (if Public debt ratio>threshold)	96.969	484.72	1089.986	-248.498	-637.302
	*0.000****	*0.602*	*0.244*	*0.97*	*0.065**
Constant (if Public debt ratio≤threshold)	0.435	0.047	3.354	-1.105	
	0.129	*0.929*	*0.519*	*0.877*	
Constant (if Public debt ratio>threshold)	-6.281	-0.43	-2.103	0.520	
	*0.000****	*0.44*	*0.685*	*0.94*	
Observations	41	39			41
R-squared	*0.959*	*0.889*			*0.941*

All the variables are in first-differences, except the error correction term (ECT)

p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Figure D.1: Likelihood ratio test for the threshold (original specification)

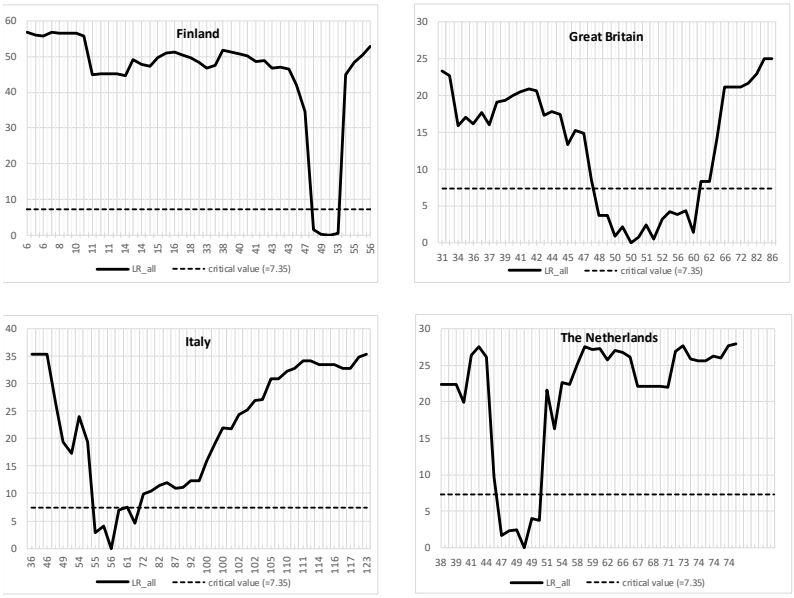
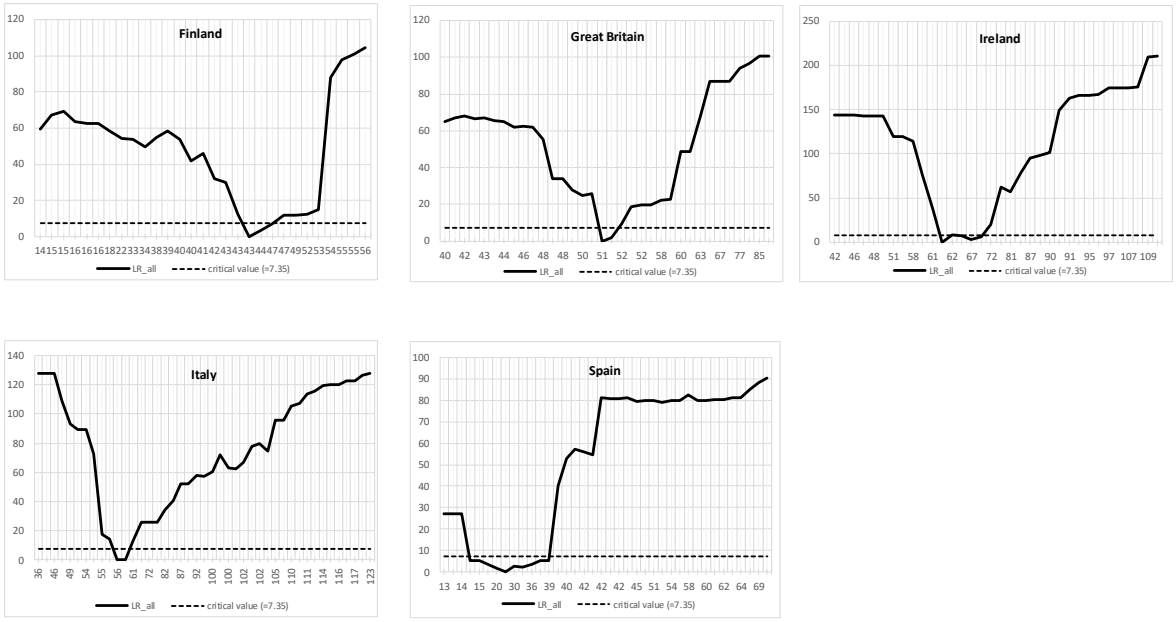


Figure D.2: Likelihood ratio test for the threshold (robustness specification)



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